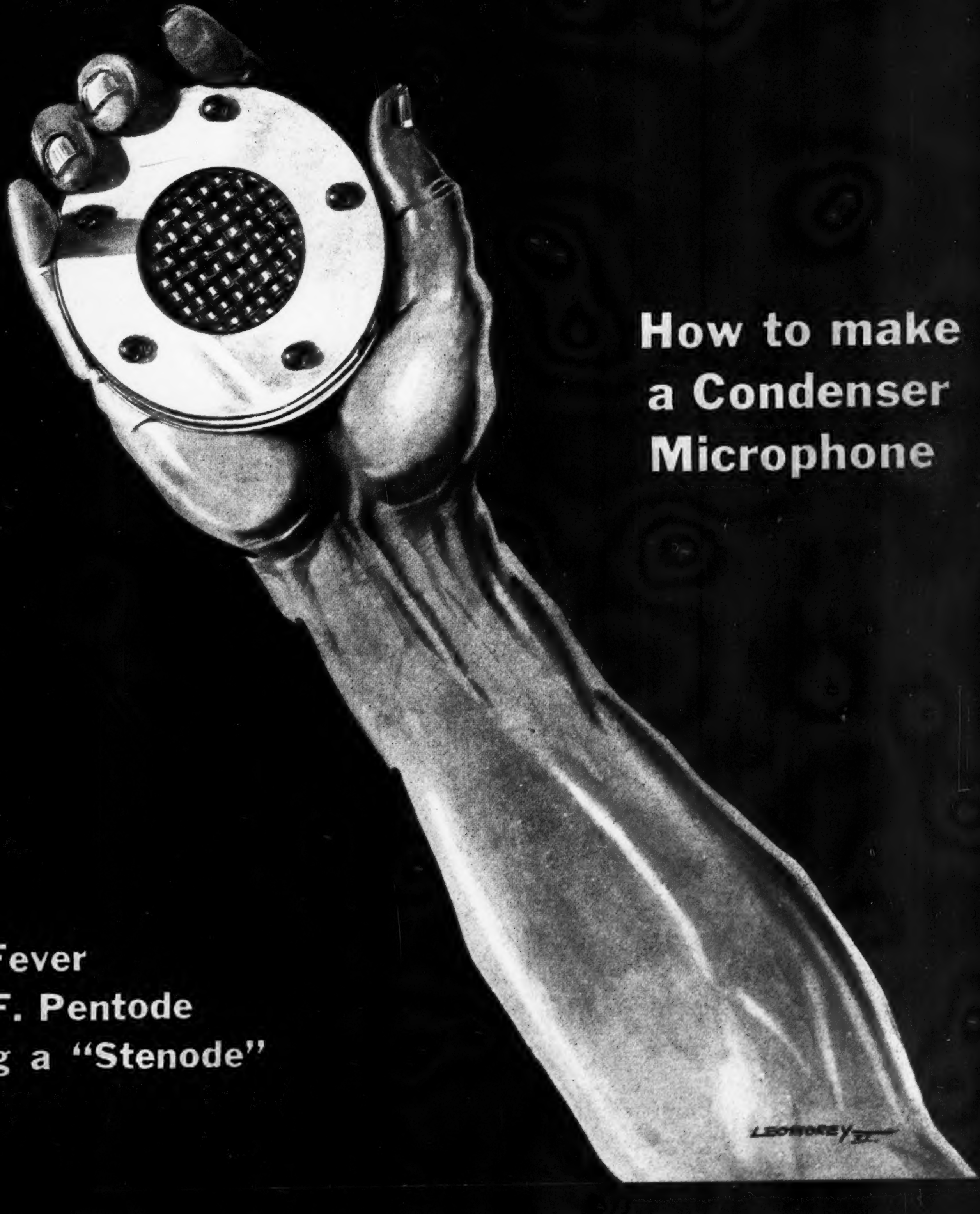
SERVICING RADIO SETS

RADIO NEWS



How to make a Condenser Microphone

Radio Fever
The R.F. Pentode
Building a "Stenode"

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VOLUME XIII April, 1932 NUMBER 10

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The Editor—to *You*

IN a radio journal of international scope, *accuracy* must be one of the prime requisites; accuracy in relating the fast-moving development of broadcasting, in both its general and technical departments; accuracy in describing new applications of radio principles in the strictly radio as well as the associated fields of electronics; accuracy in illustrating the details of specific set constructions; accuracy in statement of fact and in mathematical conceptions, formulas, diagrams, charts and illustrations; these are essential if the information contained is to be accepted and relied upon by as large a group of readers as are now reading every month's issue of RADIO NEWS.

* * *

FOR this purpose, RADIO NEWS maintains a research laboratory where a careful check is made on developments described in the magazine, where new principles are tested out, where accurate solutions to technical problems are worked out for our readers. On this page is a photograph of a small corner of the laboratory where first-hand technical information is now being obtained in connection with microphones, amplifiers and other units designed to ameliorate the affliction of deafness. Some months ago RADIO NEWS decided to investigate this field to determine to what extent apparatus built on radio principles could be used to help the hard-of-hearing. This work is progressing and a series of articles now running is the answer.

* * *

IN THIS laboratory are designed or built many of the various receivers described in the magazine, and outside designs are tested with respect to their performance. Other work in the laboratory consists in checking statements of our authors, actually trying out and testing the ideas incorporated in their articles. Another specialty of the laboratory staff is the checking of all mathematics, diagrams and charts appearing within the pages of RADIO NEWS.

* * *

WITH this policy in mind and equipped with the machinery for carrying it out in principle and in practice, the Editors feel they are producing a journal that can be relied upon by the engineer, research workers, experimenter and serviceman as an accurate and authoritative medium for the dissemination of news pertaining to radio development.

* * *

THERE come across the Editor's desk many letters containing a paragraph such as this: "Could you possibly put me in touch with a few American 'fans' with the idea of comparing notes, exchanging views, magazines, etc. I am interested in short-wave work and superheterodyne reception, and if any Americans would like to correspond with me, I would exchange British magazines with them. John R. Hiscock, 25, Sandbrook Road, Stoke Newington, London, England."

We shall be glad to place such letters on the Editorial page, when space permits, in the hope that our readers will exchange views in this way, and this brings up the matter of a letter from the President of the Anglo-American Radio Society. It reads as follows: "I feel sure that a large proportion of your readers will wish to avail themselves of the new no-membership fee scheme of the Anglo-American Radio Society. In June, 1931, owing to the world depression, membership fees were abolished and anyone desiring to join the Society has merely to send his or her name and address to headquarters at 11 Hawthorn Drive, Willowbank, Uxbridge, England.

"The objects of the Society are to aid radio enthusiasts and to promote peace and good will between nations.

"As the society has no funds other than those subscribed, members are asked to enclose an international reply (stamp) coupon when replies are desired.

"Members may obtain information regarding parts, radios or stations freely. Members will also, if desired, be put in touch with other members in all parts of the world. We have members in the United States of America, Great Britain, Irish Free State, Costa Rica, Honduras Republic, Cuba, Jamaica, Hawaii, Australia, Canada, India, Siam, Egypt, Gibraltar, Belgium, Holland and Austria.

Trusting we may have the pleasure of enrolling many new American fans." Leslie W. Orton, Honorary President.

* * *

REFERRING again to our work on Hearing Aids, the Editors invite all servicemen who are building, demonstrating or selling the RADIO NEWS Ear Aid to register their names and addresses with us. The Editors will use this list as a reference in answering letters from readers who are hard-of-hearing. We wish to be able to refer these readers to the nearest servicemen from whom a demonstration on the Ear Aid may be obtained. Readers who wish a demonstration are also invited to write to us for this reference. Simply address your letters to the Hearing Aid Department, RADIO NEWS.

* * *

AN interesting note from E. H. Anderson, director of the New York Public Library, is as follows:

"We regret to note that Volume 12, Number 1, of RADIO NEWS is not now available in your office. In view of the importance of completing our files, we venture to make a suggestion, that a notice be placed in a forthcoming issue of RADIO NEWS that the number mentioned is needed in the New York Public Library file and that the favor will be appreciated if a reader, who no longer needs his copy, will present it to the library. We shall be grateful for any assistance you may render us in securing this missing issue."

E. H. ANDERSON, Director,
The New York Public Library,
New York City.

* * *

WE HOPE that some generous reader will supply the issue to this institution that is serving millions yearly, as, unfortunately, our supply of this back issue is completely exhausted.

Laurence M. Cockaday

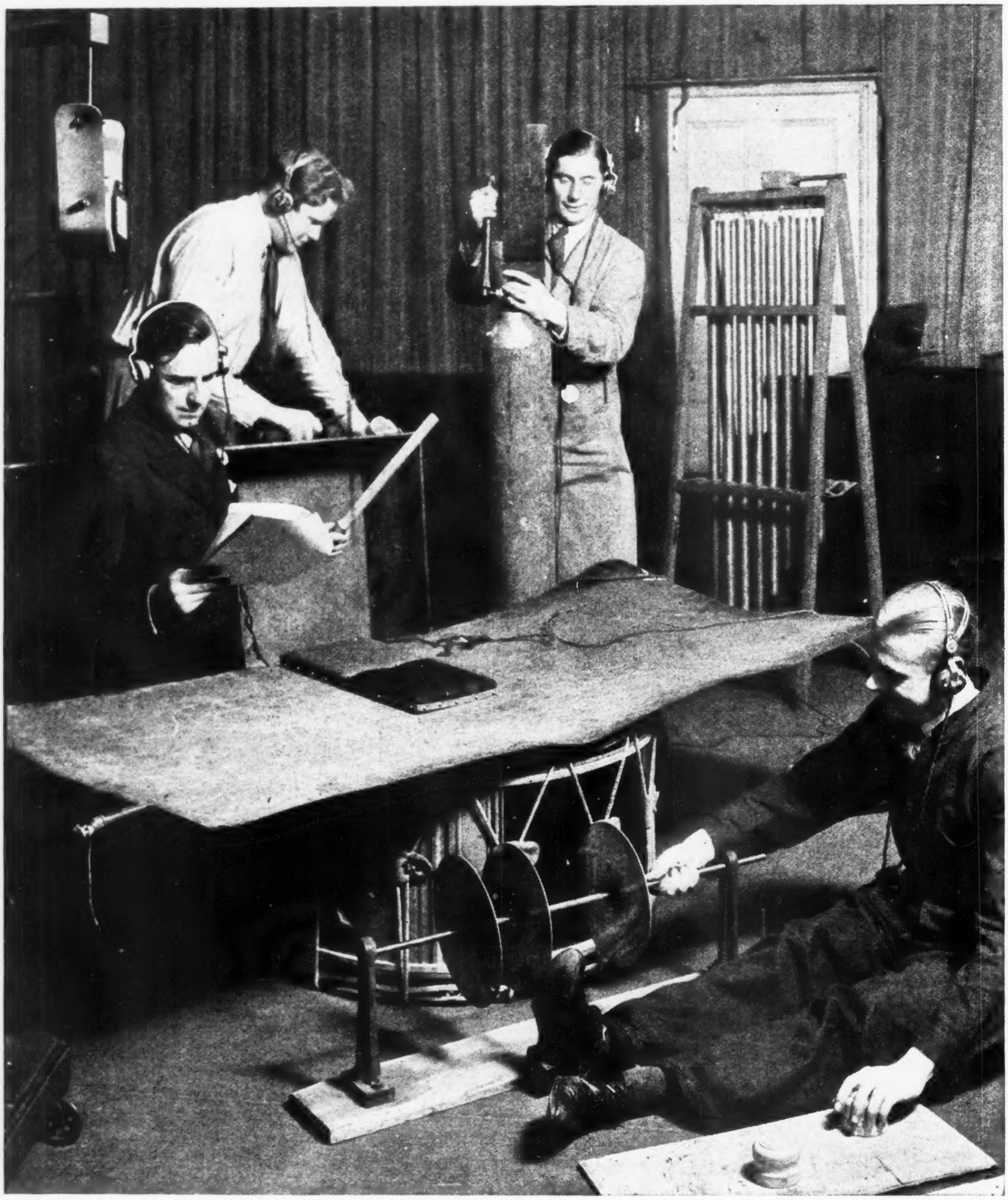
Gives Ample Information on Radio Trends

Wherever you see a new development in radio receivers or transmitters you will discover either a new tube or a new use for an existing tube. The development of new receivers is predicated on the development of new tubes. As a result, the receiver manufacturers look towards the latest discoveries of vacuum tube engineers before deciding on new seasons' circuits. The importance of the vacuum tube is by no means attached to the radio industry alone. Although a product of the radio laboratories, the vacuum tube has also proven to be an invaluable asset for industrial and scientific workers. Radio receiver manufacturers are, however, the logical persons to produce industrial devices utilizing the vacuum tube. The numerous uses for the tube in electrical, mining, medical and other fields can be more satisfactorily handled by radio manufacturers than any other group. And the radio engineer is best equipped, technically and practically, to develop these allied lines.

I have read RADIO NEWS *since its inception and notice that it describes radio developments that have never been published before. They are original stories, containing sufficient details to give readers ample information on latest radio trends.*

George Lewis

Vice-President,
Arcturus Radio Tube Co.



B. B. C. Photo

Although Seldom Heard Of, These Men Make Broadcasts Realistic

Scene in the Sound Effects Studio, where these wide-awake young fellows, happy in the knowledge that they are adding to your enjoyment of the radio programs, are busily engaged making the sounds of train and boat whistles, horses galloping, airplanes buzzing, chains rattling, the bustle of traffic, etc., to accompany the oral text of a broadcast playlet. Theirs is not an easy task, as they have to listen-in with headphones for their cues, which must be followed immediately by the proper sound, made in the proper way upon the correct "gadgets"

Radio News

VOLUME XIII April, 1932 NUMBER 10

IT'S A MAN'S JOB

Behind That Microphone

An Interesting Story of the Little-known But Important Jobs at Which Many Efficient Radio Men Toil in Bringing Broadcasting to Its Present-day Position of Perfection. It Is Entirely Possible That There Are Numbers of Our Readers Who Could Qualify, After a Bit of Efficient Study, for Some of These Positions Which Are Full of Interest and Remunerative

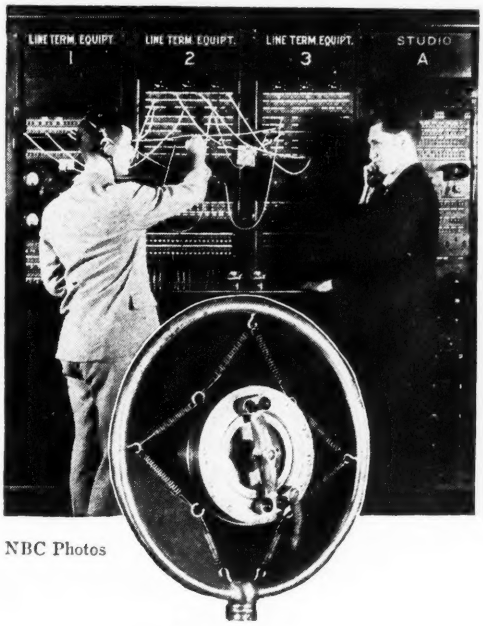
By **Albert Pfaltz**

IN the theatre the inspiring cry has always been, "The Show must go on!" In broadcasting—a show business on an international scale—the same spirit prevails. And it is the radio engineer and his associates who now manipulate the intricate networks of the present day, who plan and execute the broadcasting of world news events, who make possible the maintenance of high quality radio service.

The casual studio engineer may notice the control room engineer sitting behind the glass window of his booth busy at the monitoring panel. He may also notice the announcer's apparatus with its switches and tiny colored lights. His main interest, of course, is in the program this side of the microphone. If he is the average radio fan he knows nothing whatever about what happens to the program between the two physical points—one of them visible to him—of the studio microphone and the antenna of the broadcast transmitter. What happens to the sound in that comparatively short and instantaneous travel is not his concern in the slightest. It is one of those things that he takes for granted.

An Important Work

And yet the safeguarding of a program between those two points is a work of engineering art as important, in every respect, as that of the artists and announcers. Scores of trained engineers are constantly on the job, planning, testing, monitoring. Taken in *toto* their work may be described as designed to preserve two things in any given broadcast—fidelity and continuity.



NBC Photos

TENDING THE LAND LINES

Have you wondered just how that program from cross country is switched so quickly and at exactly the right instant to your local station's antenna? Here are engineer workers who tend the line terminal equipment panels in connecting the proper stations with the desired program, although they may be separated by thousands of miles

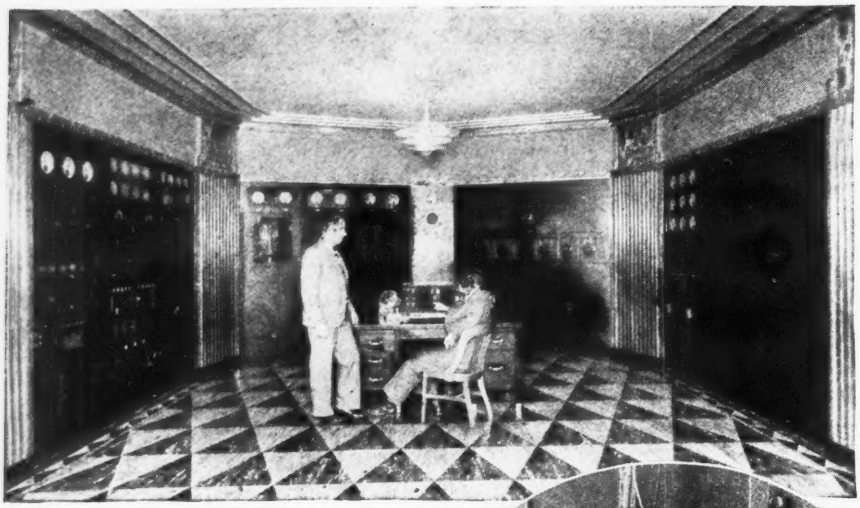
Broadcast programs originate either in a studio or in the field, the latter being otherwise known as "Nemo" pickups.

The first named type is comparatively simple. For a brief picture of the engineering methods employed let us look in at 711 Fifth Avenue, in New York, NBC headquarters.

It is the announcer who actually controls the switching of a program from the studio, where a broadcast is about to begin or end. Let us assume that the artists, the announcer and the control room engineer are waiting for the preceding program to end and receive their cue to begin. The announcer, who is standing before a row of push-buttons and lights on a little panel, is listening by means of headphones to the concluding minutes of a program coming from another studio. At the conclusion he receives a signal which tells him that the other program has been completed and that his studio now "has the air."

Accurately Timed Switching

Our announcer now strikes the familiar four-note chimes and gives the station identification. These chimes are utilized as switching cues by individual stations and supplementary networks joining or leaving the chain. A problem of synchronization arises here as the smaller chains which tap the basic networks at a distance from New York may take program service from either the basic Red or Blue networks. If one network program finishes a few seconds ahead of schedule the announcer for the other network takes control of both for the time necessary to give the chimes. All per-



TRANSMITTING ROOM AT WEAF

Shown at the control panel is Gerald Gray, in charge of the station, and, standing, Raymond Guy, radio engineer of the NBC. These men are in charge of complete operations and repair of the powerful 50-kilowatt transmitter shown at center. At the left is the low-powered unit panel, including modulators and frequency-controlling devices. At the right is the power-control equipment and a dummy antenna system

AT THE CONTROL PANEL

Fred Hanck seated at the control apparatus at Bellmore. He is looking at the oscillograph, on which a continuous moving picture of the broadcast's signals may be observed

sonnel—announcers, control room engineers, etc.—are in possession of essential information concerning the distribution of a program and either the announcer or the studio engineer can set up or release the required program channel.

The duties of the studio engineer who monitors the program from the control room are fairly familiar. It is his job to control sound levels and faithfully follow his program cues, such as those calling for the fading down of music behind an announcement or the balancing of microphones.

Each studio has a twenty-four-hour reserve storage-battery supply for use in case of failure of the commercial power source.

So much for the individual studio set-up—and there are eight such at headquarters in New York.

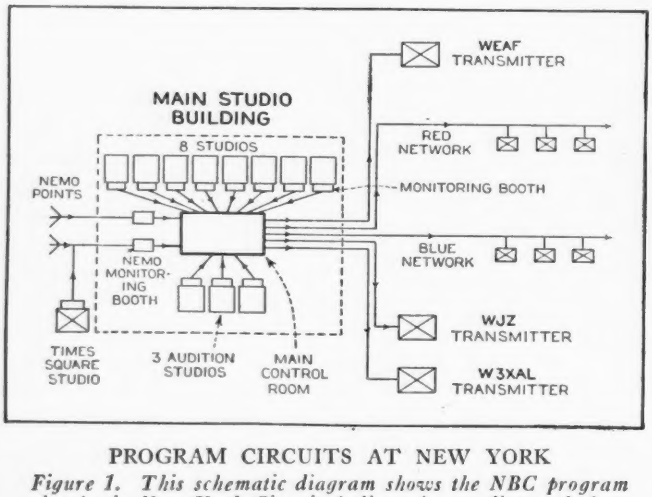
Because of the fact that several programs may be on the air simultaneously, from either studio or Nemo points or origin and that combinations of local transmitters and networks are continually shifting, it may safely be said that the main control room at headquarters is the nerve centre of operations. Responsibility for the operation of studios and the distribution of programs is centered here.

Some idea of the complexity of the layout immediately surrounding the main control room may be obtained from Figures 1 and 2.

Through constant supervision at this point, programs are dispatched to designated places at proper levels and at definite times. This requires two things—an interlocking system for transferring the outputs of various studios to one or more distribution channels and facilities for checking the program at important points.

The control room supervisor has available volume indicators and a loudspeaker, the former showing output levels of studio and line amplifiers while the latter may be connected to either of these points. In addition, the signal light shows whether the local transmitters, WJZ and WEAF, are "on" or "off" the air, and a neon lamp indicates whether the carrier is being modulated and, roughly, the degree of modulation. A circuit can be quickly patched around any faulty unit as the input and output connections of most of the equipment in each studio appear on jacks in the control-room apparatus.

Furthermore, telephone connections to all monitoring booths and telegraph circuits to all networks and local transmitters are avail-



PROGRAM CIRCUITS AT NEW YORK

Figure 1. This schematic diagram shows the NBC program circuits in New York City, including nine studios and three audition studios, connecting to the main control room

SPECIAL BROADCAST SWITCHBOARD

These panels, connected in circuit, took care of the broadcast of an "Air Raid" over New York City. Seated at the board are George Milne, division engineer; Ferdinand Wankel, engineer, and William B. Miller, director of special broadcast events of the NBC system

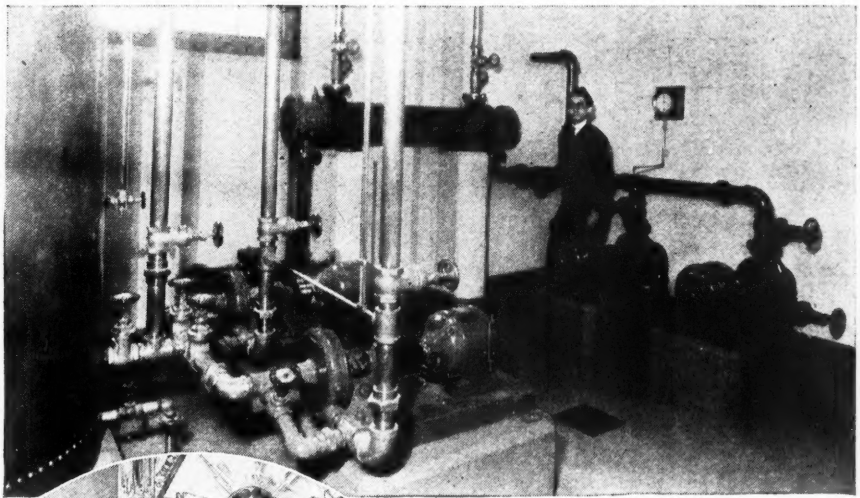
able to the control-room supervisor.

Present-day broadcasting depends, very largely for uninterrupted service, on the efficiency of the network of telephone lines which connect cities, studios and transmitters. The telephone company is responsible for the maintenance of program service between network stations. Few persons realize that dozens, and sometimes hundreds, of wiremen are stationed at strategic points during an important network program where, because of the single factor of geography, almost any kind of climatic condition may be encountered—to say nothing of an "act of God" which might cause a truck loaded with high-explosives to collide with a telephone pole!

However, engineers of the broadcasting company frequently check the transmission characteristics of all long-line networks. The shorter local lines, which seldom give trouble, are checked daily and then rechecked immediately prior to a broadcast. Frequency characteristics are also taken covering the entire circuit from microphone to antenna.

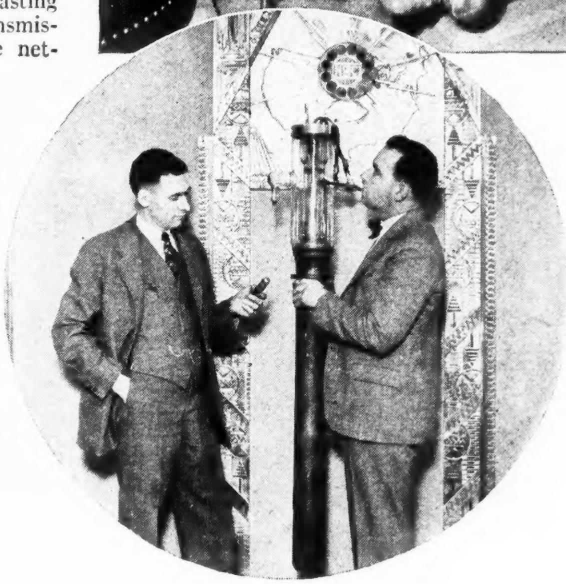
Before outlining the more intricate problems involved in the handling of a big news event broadcast, such as the arrival of the air armada over New York or the initial trip of the Graf Zeppelin, let us consider the transmitter—the comparatively new WEAF, for example, which is the last step in the engineering chain required to put a program on the air.

The new $300,000 transmitter was installed in a recently constructed wing of the WEAF operating building at Bellmore, Long Island. O. B. Hanson, manager of plant operation and engineering, and Raymond Guy, radio engineer, declare that this apparatus, which embodies the latest ideas of radio transmission, now makes every sound picked up by the microphone audible to listeners as far away as New Zealand.



LONELY, BUT IMPORTANT

Here is Engineer Dietsch, who has complete control and operation to the cooling equipment in the pump room of the WEAF transmitter building. If this equipment failed for only a short period of time, the transmitter would go off the air and thousands of dollars' worth of tubes and associate apparatus would be ruined



A $1,500 VACUUM TUBE

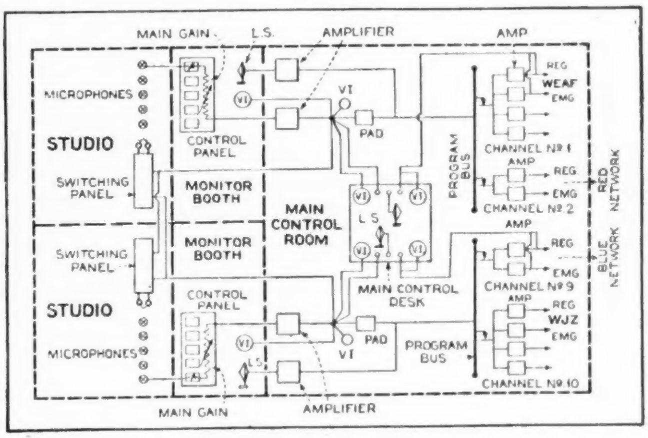
Here are the station engineers holding the largest size transmitting tube and comparing it with the small 199 receiving tube employed in early battery-operated receivers

The station operates with a maximum power of 50,000 watts. With the modulation increased from less than fifty to one hundred percent, listeners receive the signals several times louder. High and low notes, sibilants and certain sounds, heretofore heard indistinctly or lost entirely, now are transmitted perfectly. The equipment includes the latest refinement in crystal-control apparatus to hold the station on its assigned wavelength, giving increased frequency stability. Careful observations show that the fluctuation is only ten cycles in 660,000. The transmitter employs two 100-kilowatt type tubes which stand five feet high and require thirty gallons of water, per-minute, to cool them.

The central control panel gives (*Continued on page* 884)

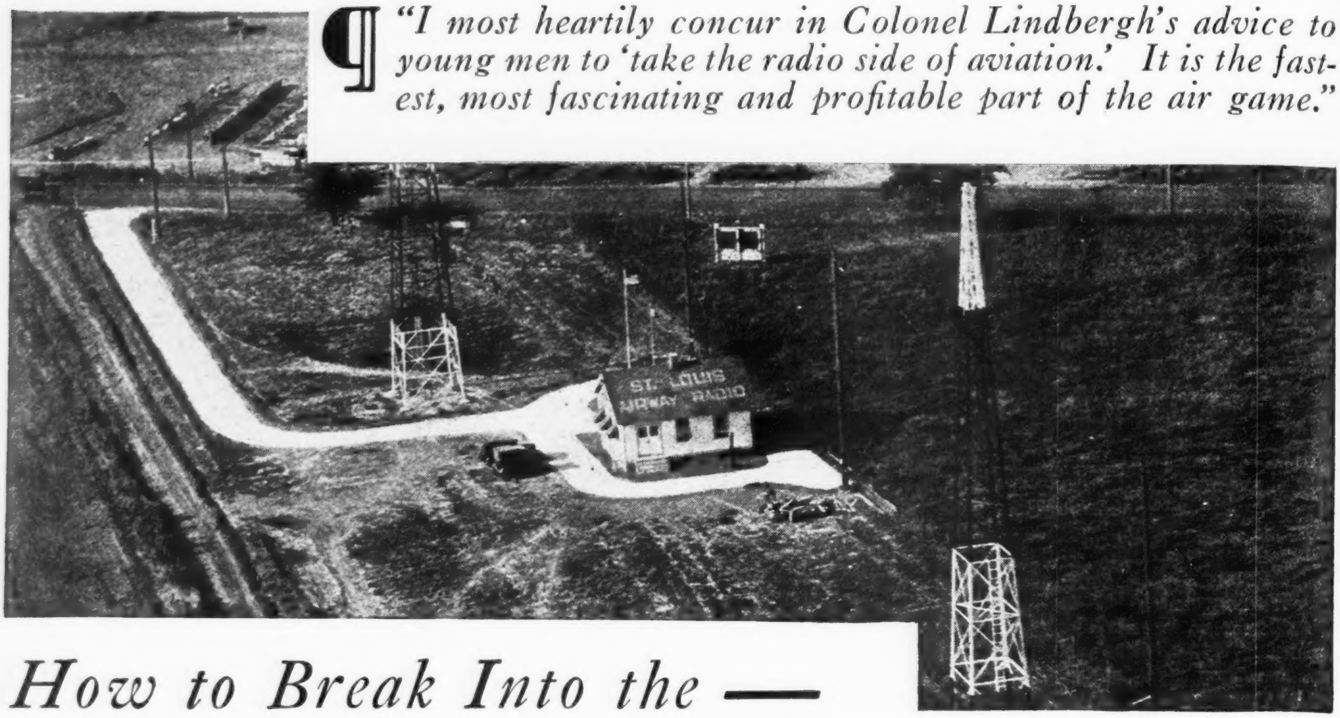
CONTROL ROOM OF TIMES SQUARE STUDIO

You never think of these watchful engineers on duty when you listen to a program from this famous studio, but they are there with eyes, ears and brains alert to conquer any emergency that might tend to interfere with the broadcasts



CONTROL PANEL CIRCUITS

Figure 2. Schematic diagram of the actual program circuits to the studios and to the channels of the control room shown as part of the diagram in Figure 1



"I most heartily concur in Colonel Lindbergh's advice to young men to 'take the radio side of aviation.' It is the fastest, most fascinating and profitable part of the air game."

How to Break Into the — Aviation Radio Game

By Lieut. Myron Eddy*

AVIATION radio operators—what sort of men are they? Having trained hundreds of them, I am often asked that question. Wherein do they differ from ships' radio operators or the men who operate the broadcast station equipment? Interesting questions, these. The answer is that they are not so very different. In fact, they are in many instances the same men—ships' operators often take up aviation radio work. But to make good they must like aviation and be something of a mechanic. To "like aviation" usually means that they are familiar with airplanes and engines, that they would like to fly, that they would be unafraid in the air. There are many strictly "ground" jobs for radio operators, but I think that airplane operators are the ones who usually get the most fun out of their job.

First "Try Your Wings"

So if you are thinking of taking up "the radio side of aviation," which Colonel Lindbergh not long ago advised was "the coming thing," first fly a bit. Get your flight reactions established by flying. And do something while you are in the air. A radio operator concentrates on his work, every minute of every flight. You must learn to do the same and still not be tired. Pan-American radio operators must all accept flight duty when assigned, even though employed at radio stations on the ground. The first of our questions are answered, then—aviation radio operators should be the sort of men *who do not get air-sick.* In this respect they must be different from the ship's operator who may be relieved by another operator if he becomes sea-sick. There is no relief operator aboard a plane. In fact, the operator should be able to relieve the plane mechanic if the latter is overcome with gas fumes or injured while in flight. On most planes the operator is referred to as the "radio mechanic" because he serves as both radio operator and plane mechanic. Sometimes he is the *only* mechanic aboard. In this case he usually holds an airplane mechanic's license. In every case he must hold a commercial radio operator's license—a broadcast operator's license simply will not do. Because it seemed that there was a special sort of operator needed for airplanes, the Department of Commerce (Radio Division) authorized, nearly a year ago, a special Aircraft Radio Operator's license—Commercial Third Class.

A working speed of only fifteen words code is required to secure this class of license. This is because a greater speed in transmission and reception aboard airplanes is unnecessary and undesirable, accuracy being more essential than speed. Indeed, accuracy and dependability are the chief professional qualifications desired in the airplane radio operator. The ability to maintain the radio set and get the messages through on schedule is the main thing.

TESTING RADIO BEACON
Mr. H. L. Clemens, Assistant to Radio Engineer, testing the beacon and weather receiver on an Eastern Air Transportation mail plane

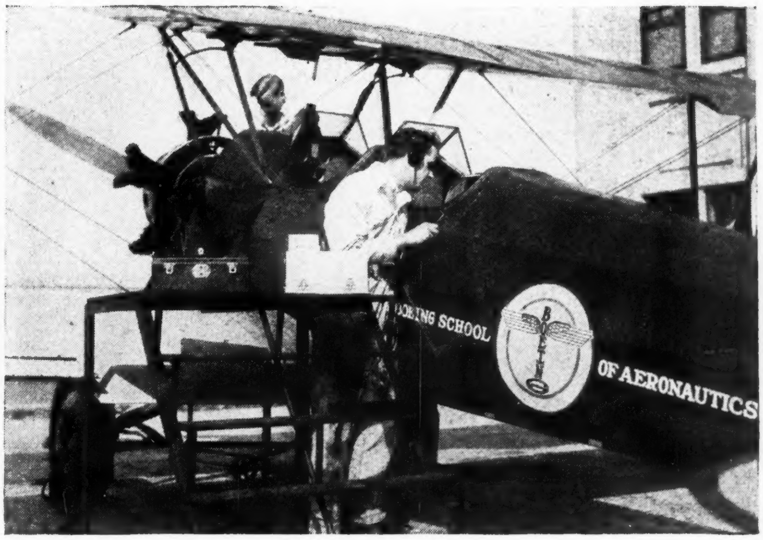
Airplane Equipment

Consider the equipment to be maintained and operated: there is a transmitter, two receivers and sometimes a course indicator. Generator, batteries and antennas must also be watched. Regulations governing transmission of messages must be known and adhered to and schedules handled "on the dot." The operator should also know the Airways—every light and radio beacon, the bearing and distances between them and the type of terrain flown over. The pilot will tell him the air speed being flown. The compass will indicate the amount of drift caused by wind. Between messages the quick operator will be able to estimate accurately the ground speed being made and therefore the time of arrival to be radioed to the next airport ahead. Yes, the radio operator aboard a transport plane is a

*Author, Aircraft Radio.

very important man, so far as flight is concerned.

Now what about his buddies on the ground? There are two of them, a radio service or maintenance man at the airport who will overhaul the plane set at the end of the run, and an Airways station operator who handles the actual message traffic with the plane. Their work is also important. The reports of these two men make or break the young plane operator; if the messages do not come through and the airport maintenance man locates a fault in the set that could have been remedied in the air, the plane operator is probably "grounded" for a while, to spend weary hours in disgrace washing down planes and playing radio messenger boy. Messages must get through! As a matter of fact, they usually do get through, thanks to the combined efforts of the plane operator, the station operator and the maintenance man.



AVIATION RADIO SERVICEMAN AT WORK
Testing the bonding of a training plane by comparing with a receiver which has been set outside of the plane

Ground Station Operators

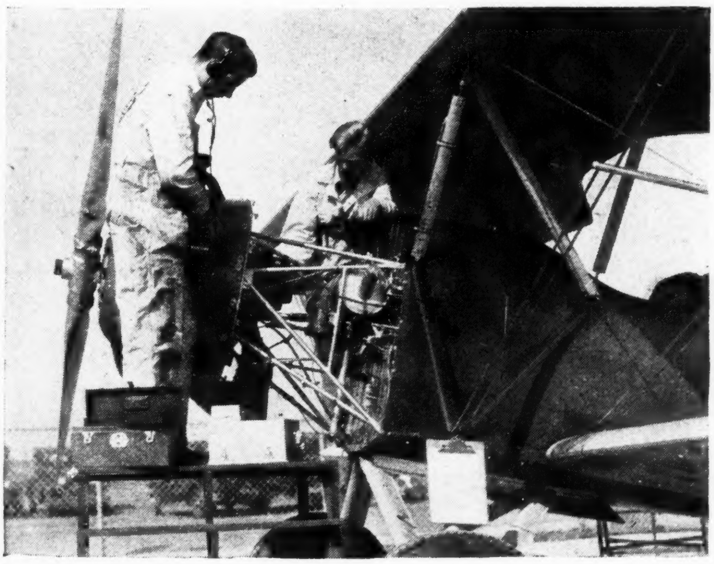
The good station operator works his set all the time. He services the set as he operates it. He "picks up" the plane calling other distant stations first; then he takes over the handling of traffic at the most convenient time according to existing schedules. Every minute of every hour is scheduled, either to a particular station, or to planes east, south, west, north. He hears them all in sequence and at the proper time exchanges a brief call with each to establish contact. As each, in turn, approaches and passes, he "clears" them, reporting their position by land wire or teletype machine to the proper flight-division airport.

Sometimes the Airways station operator becomes an impromptu radio serviceman or plane mechanic. If a plane lands at his station he may become both, because at every stop made, and especially whenever there is a non-scheduled landing, the engine, plane and radio set are inspected and tested. If it is an emergency landing, full details must be forwarded to the division headquarters at once, without interfering with the work to be done on the plane. In this case the relief operator is hurriedly called and put on the key while the regular operator hurries out to meet the plane, helping to man the landing lights at night if it is an "intermediate" field.

Requirements and Rank

These station operators are always assistants to the field superintendent and usually make up and send weather reports as a part of their regular duties. They are all required to be not only radio-telegraph but radio-telephone operators and must therefore neither stutter nor lisp! Living quarters are usually provided and at government stations the salary received is from $1640 per annum, up. Upon being appointed to one of these stations there is a probationary period of six months, during which time the probationer may qualify at the kitchen sink or solo at the lawnmower. But they like it! Day and night great airplanes soar by overhead, speeded on their way by work at the key and the microphone. Through storm and fog, the station man keeps his radio beacon sending out its guiding beam to carry the pilot straight through to a safe landing. There is a thrill in this. And yet the station job lends itself to domesticity. The married man at an Airways station eats and sleeps "home" every night. For this reason the older men with families usually end up at either an Airways station or at an airport.

And what does the radio serviceman at the airport do when he takes over the set at the end of each run? Briefly, he works the set. If it won't work, he finds out why and replaces the equipment that is faulty. He charges the battery. He sets up the generator on a test bench and gives it a speed run. He loads a "dummy" antenna and runs the transmitter full blast, noting its maximum output into this "dummy" antenna. He tests every tube in the receiver and listens for "distance" to determine its sensitiveness. If it is more noisy on the plane than off, he checks up on the airplane engine's ignition system to see if it is properly shielded and also if the plane itself is properly bonded to form a perfect counterpoise. In performing these tests he strings the trailing type antenna out in different directions to nearby poles, in order to determine any directional tendencies. The results of all tests are recorded and a copy furnished the plane operator before the next flight. Then, just before the take-off, the entire radio set is tested by both serviceman and plane operator, the latter signing the test report as "condition satisfactory for flight work."


OVERHAULING IGNITION SHIELDING SYSTEM
Aviation maintenance men checking the ignition shielding system of a plane so necessary for quiet operation

Employment Conditions

The situation regarding employment is peculiar and the governing facts are of interest. There are now nearly 400 radio-equipped planes in the United States and there will be more each succeeding year, all licensed as mobile stations. All are required to be manned by licensed radio operators. This influences the employment situation. Approximately 75% of the air-transport companies use radiophones on their planes. Many of these planes do not carry radio operators, although there must be one pilot aboard holding a radiophone license. Pan-American is a notable exception—they fly mostly over water, communicate longer distances and use radio-telegraphy exclusively. They say it is the only thing for distance, accuracy and dependability. They hire experienced, first-class commercial operators only. Many of these operators qualify for an airplane or engine mechanic's license. This license can only be secured by one having had experience on a plane, and an operator holding it usually makes more money (*Continued on page* 874)

HOW HIGH-FREQUENCY ELECTRIC FIELDS

RADIO

Radio sciences, heretofore used various forms, have opened a new author tells of recent investigation nection with their therapeutic ture to produce protective fever in

***By* Irving J.**

Photos Courtesy Amy, Aceves and King

A PATIENT UNDERGOING TREATMENT

In this machine the patient is rolled in blankets and laid upon a rubber air-cushion between the two large condenser plates. In the right foreground is the control board for adjusting the machine

NOW it is possible, with the use of radio waves produced by machines similar to radio transmitters of the short-wave type, to heat up the human body and to give it the therapeutic benefit of raised temperature (fever) in a purely physical way, without the use of chemicals. A new and valuable tool is thus presented by the physicist to the physician; a clean process which can be easily controlled without the aid of the drug store and the apothecary.

What is fever? Fever is an increase of the normal body temperature, together with a general functional derangement, a higher pulse rate, etc. A body with raised temperature has marked changes in its metabolism; for instance, it is able to eliminate poisons, destroy bacteria and other destructive elements of the body at an increased rate.

This is of tremendous importance for maintaining health. For instance, in a body infected with bacteria, the heat-regulating mechanism automatically raises the temperature in such a way that the disease virus finds less favorable living conditions at the new temperature.

But the diseased body cannot always help itself in a sufficient degree. It has been found necessary in many instances to raise the temperature of the body by chemical means, *e.g.*, the injection of proteins, malaria and other germs, which in producing the curative fever often produced other unfavorable reactions.

Fever in a Limited Area

If there was only a small part of the body which should have been raised to a higher temperature, it was necessary to heat the entire body, although, naturally, a limited area can stand a much more severe temperature increase than a general treatment.

Now radio has made it possible to heat up the desired limited areas to temperatures far above those obtainable by chemical means, and under fully controllable conditions.

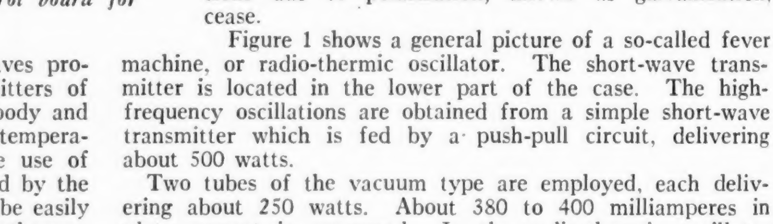
What is this wonder instrument which can perform these effects, and how does it work? This so-called fever machine, in its essential parts, consists of a transmitter similar to a radio transmitter for short waves. A high-frequency field is generated by this transmitter, but the energy is not radiated into space by an aerial system, but concentrated between two or more condenser plates. In this high-frequency field, without any galvanic contact, the body of the patient is placed, the body acting as a dielectric between these plates.

Every electric current, direct current as well as alternating, heats up the body it passes into. For the body to stand a satisfactory amount of current with an analogous temperature increase, without undue changes in its physiological and chemical composition, a high-frequency current has to be used. Only if frequencies of the order of millions of cycles per second are used do the excitation of muscular contractions, known as faradization, and of chemical reactions due to polarization, known as galvanization, cease.

Figure 1 shows a general picture of a so-called fever machine, or radio-thermic oscillator. The short-wave transmitter is located in the lower part of the case. The high-frequency oscillations are obtained from a simple short-wave transmitter which is fed by a push-pull circuit, delivering about 500 watts.

Two tubes of the vacuum type are employed, each delivering about 250 watts. About 380 to 400 milliamperes in plate current is consumed. In the radio-thermic oscillator shown above two tubes, type 504-A or its equivalent type UV-204-A, are used.

The transmitter works on 110 to 115 volts, alternating current, of 50 to 60 cycles, and requires about 15 amperes input from the current supply.



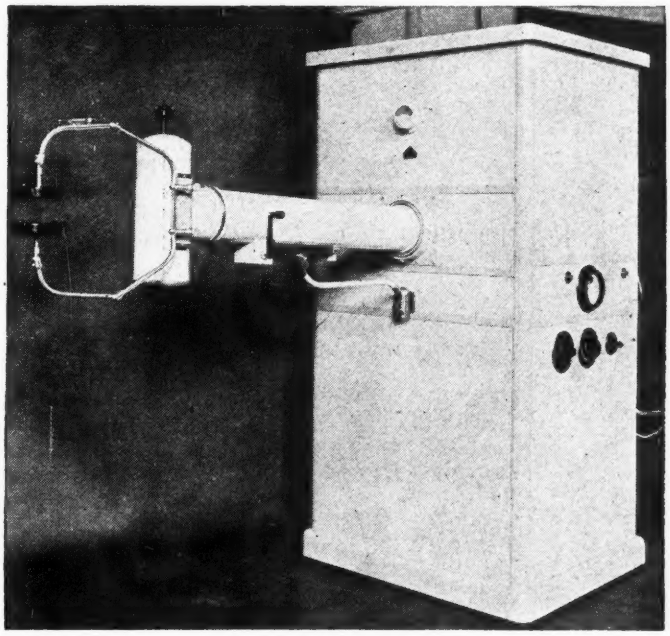
RADIO-THERMIC APPARATUS IN FULL VIEW

Figure 1. This photograph shows the construction of the high-frequency tube generator used in the fever machine. At the extreme left is the step-up transformer. The inductance coil and vacuum tube are shown at center, as well as the sliding frame in which the condenser plates are let down when not in use

ARE USED IN MODERN MEDICINE TO PRODUCE

FEVER

primarily for communication in field beneficial to humanity. The in using short radio waves in con- effects in raising the body tempera- killing germs of a number of diseases



EUROPEAN TYPE OF APPARATUS

Figure 3. This fever machine was developed by Professor Esau, and works on ten meters. The high-frequency field can be concentrated between the two small condenser plates shown at the end of the treatment tube. It makes possible a much more intensive treatment with the short waves over an area of the body that can be kept relatively small

Saxl, Ph.D.

The plate voltage is produced by a transformer shown at the left side of the picture in Figure 1. The high-tension current is rectified by two full-wave mercury-vapor rectifiers, and the voltage variations are smoothed out by filters.

The inductance of the high-frequency circuit consists of about nine windings, with coils of about 10 inches diameter. The capacity in the transmitter circuit are the two plates located at the top of the cabinet, and the patient is placed between them as a dielectric.

The Circuit Essentials

This apparatus is about 6 feet long, 36 inches wide and 30 inches high. The condenser plates slide down into slots without removal. The instruments for controlling the current intensity and the wavelength (at the right side of the picture) are placed in such a way that they are easily accessible.

This machine delivers about 10 megacycles, corresponding to a wavelength of about 30 meters. Figure 2 gives a circuit diagram of this machine. The diagram, together with the data mentioned before, is self-explanatory. V_1 and V_2 are rectifier tubes in a full-wave circuit, from which the plate voltage is taken for the operation of the vacuum tubes V_3 and V_4. These operate upon the self-inductance coil L_4 in push-pull and create the high-frequency field applied around the plates of the condenser C_{10}, between which the patient is placed.

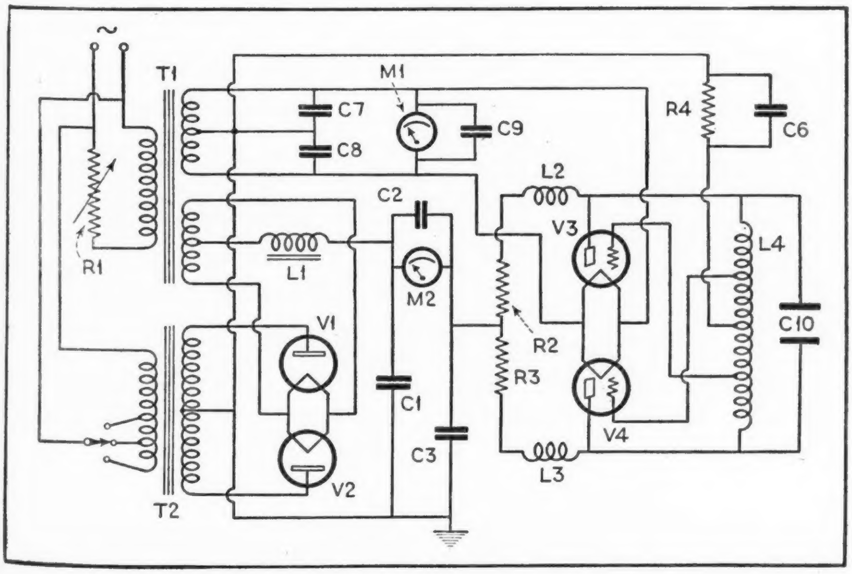
Apparatus of a similar type is also used by A. Gosset, G. Lakhowsky and others in France, and by Esau in Jena. The General Electric Company also has entered this field. Gosset and his collaborators had an adaptable apparatus which was able to work on wavelengths as short as 2 meters.

The frequency is measured by a small oscillating wavemeter circuit, consisting of an inductance, a condenser and a little flashlight bulb in series with it. For determining the wavelength, the condenser is turned slowly until the filament starts lighting. Then the wavemeter is removed as far as possible, the condenser being regulated so that the filament of the lamp just glows.

The exact wavelength of the main radiation is at that point where the filament just glows up for a single condenser reading. Care has to be taken not to burn out the lamp by moving the condenser too quickly while the wavemeter is near the transmitter, as the increase in power "grows" swiftly as the condenser approaches the point of resonance.

For working with high sensitivity, the wavemeter has to be removed from near the oscillator, so that the filament just shows a faint glow.

The machine developed by Amy, Aceves and King, Inc., in co-operation with Dr. Ramirez, of the French Hospital, New York City, uses an air mattress, upon which the patient is laid between the condenser plates; rubber and air being an excellent insulator, so that the high-frequency field is not lessened and can work within the body of the patient.

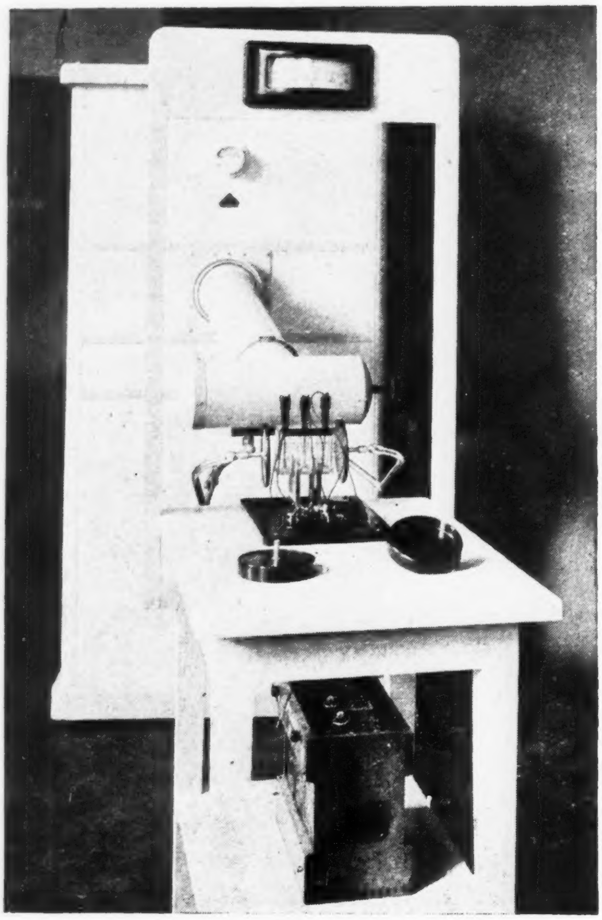


THE OSCILLATOR CIRCUIT ESSENTIALS

Figure 2. The schematic diagram for the push-pull generator used in perusing the high-frequency currents in the machine developed by Amy, Aceves and King

Method of Treatment

For heating up the patient, the entire apparatus, which is on rollers, is removed from any location near walls which contain steel, as this naturally would tend to induce high-frequency currents within the structural material. The patient is rolled in blankets and placed between the condenser plates. It has proven practical to dress the patient, first, in a woolen union suit. Thus perspiration is removed automatically and cannot accumulate, in drops, upon the skin. This is important, as these fluid drops heat up quicker than the body and cause burns upon the skin.



AN EXPERIMENT WITH THE ESAU DEVICE

Figure 5. Mounted between the operating electrodes are glass cells filled with a fluid resembling body fluids. Thus a study is made of the effect of high-frequency fields upon a "phantom" organism. Temperature is recorded automatically by means of calibrated electric thermocouples

The position of the patient is important. If we place one hand between the condenser plates, and the current is put on, the hand will feel the heat quicker if the hand is held in an imaginary plane which connects the condenser plates. The temperature increase, however, is less under equal current conditions when the hand is held parallel to the plates. This experiment can be performed easiest with one of the small condenser machines described later in this article. For heating up the patient more quickly, his feet and shoulders are arranged so that they touch opposite plates.

The apparatus is arranged so that about one degree temperature increase takes place in 15 minutes, the temperature being measured by a thermometer in the mouth of the patient. The patient is heated and kept in his warm blankets after the current has been turned off. It is interesting to note, in this connection, that the pulse rate increases for some time after the patient has been removed from the high-frequency field. The fever does not stop immediately after the patient is taken out of the condenser. Thus he keeps his "fever" temperature for several hours. Warm lemonade and tea are given him to replace the loss of fluid substance and to increase perspiration. If the fever does not stop by itself after a prescribed time, ice bags are administered. This method produces less strain on the heart of the patient and is certainly more effectively controlled by the physician than with quinine and other chemicals after malaria or protein injections.

Charts showing the temperature increase have been prepared by Dr. Ramirez, as shown in Figure 4. These also give data for the changes of the pulse rate and the respiration during the fever treatment.

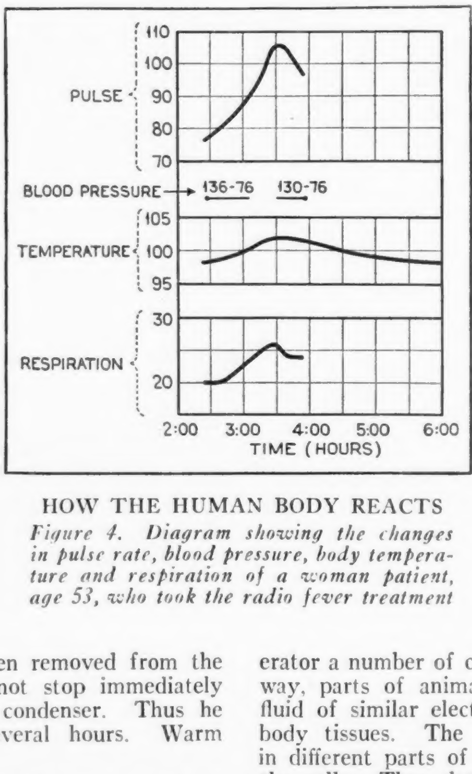
Blood Pressure and Other Reactions

There are decided changes which take place in the blood picture of the treated patient and in his other reactions. Experiments on animals have been made showing that the temperature returns to normal quite rapidly as long as the animal has not been heated over 42 degrees Celsius.* Animals heated above that temperature for a longer period of time have been killed. A decided loss of weight takes place, ranging from about two to ten percent of the body weight, according to the length and intensity of the treatment. Also it makes a great difference whether the sweating and feverish body is allowed to replenish its loss of water. There are also marked changes in the different steps of metabolism and in the non-protein nitrogen of the blood. According to Knudson and Schaible, this increased in several instances up to 200 percent. Red blood cells and total white cells are increased too, and, in addition, the microscopic analysis of the blood shows a number of immature forms of red blood cells.

Figures 3 and 5 show another improved form of machine for localized fever treatment. This is the machine of Esau and Schliephake, of Jena. The high-frequency oscillator is entirely built-in within a metal cabinet connected to the ground, thus protecting the oscillating circuit from any capacity influence of body parts near it. By using these small electrodes instead of the large ones, it is possible to produce fever in a limited area of the body and to avoid the dangerous and exhausting effects of a general fever even with physical apparatus.

The G. E. Co. has lately produced a fever machine which was demonstrated at the last convention of the New York Electrical Society, at the Engineering Auditorium. The plates of this machine are about twice as large as those of Schliephake, giving a somewhat less localized action.

With this machine Dr. C. F. Tenney, Jr., attending physician of the Fifth Avenue Hospital, treated 580 cases of rheumatism since last April, with results which were so encouraging that several patients who had come on crutches were able to discard them after a number of treatments. Whether this fever machine will give a permanent cure in severe cases of arthritis is still too early to determine. But certainly the cures already effected are almost as miraculous as the "wonder cures of the saints." The wonders of the twentieth century are thus seen coming from the laboratories!



HOW THE HUMAN BODY REACTS

Figure 4. Diagram showing the changes in pulse rate, blood pressure, body temperature and respiration of a woman patient, age 53, who took the radio fever treatment

Short-Wave Experiments

At the short-wave experiments performed in Vienna, the physicians and other people having to do with the machines during their operation wear metal-coated laboratory coats and caps. Metal-weave ribbons were sewed upon the outside of these garments, as electro-magnetic frequencies of this range do not penetrate such shieldings.

Figure 5 shows an interesting experiment made by Dr. Esau. Between the plates of the high-frequency generator a number of cells are placed which resemble, in a rough way, parts of animal tissues. These cells are filled with a fluid of similar electric characteristics as the cell content of body tissues. The temperature is controlled automatically in different parts of the fluid by thermo-elements inserted in the cells. Thus data can be read directly on the meter on top of the instrument, with reference (*Continued on page* 873)

*Arthur Knudson and Philip Schaible, Archives of Pathology, Volume II, pp. 728 to 743, 1931.

Self-contained-power Radio Receivers FOR THE FARM

SPARTON

LYRIC

By Wm. C. Dorf

THE rural dweller with an Air-cell receiver is now able to enjoy, to the fullest extent, the benefits of modern radio. The leading radio manufacturers are augmenting their lines of receivers by taking advantage of the Air-cell "A" battery, combined with the 2-volt type tubes, for use in self-powered radio receivers in meeting an important demand and a profitable market in direct-current districts, unelectrified farms, and thousands of homes without central station service. At the present time, there are upwards of twenty different manufacturers producing battery-operated radio sets, all using the Air-cell "A" battery with these new 2-volt tubes. These sets are comparable to the a.c. receivers in tone, range and selectivity.

The manufacturers are making the receivers in both tuned-radio-frequency and superheterodyne circuits and are enclosing them in attractively designed midget-type and console-type cabinets. The high degree of sensitivity and quality obtainable with these receivers is made possible by the use of power detection, screen-grid and pentode-type vacuum tubes and permanent-magnet dynamic speakers. Features heretofore only procurable with a.c. receivers are new standard equipment on Air-cell sets, such as tone and static controls, and full-vision illuminated dials.

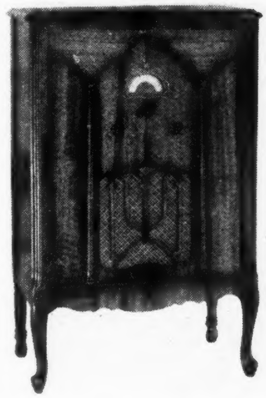
The Air-cell "A" battery is manufactured and shipped "dry." It is rendered active by filling the two compartments of the unit with ordinary drinking water and by following a few simple instructions outlined on the side of the battery case.

The Air-cell is not rechargeable and the bother and nuisance of continually recharging storage batteries or renewing dry cells is therefore eliminated.

Once the Air-cell battery has been activated it is capable of delivering a thousand hours of normal (*Continued on page* 891)

CROSLEY

SPARTON



STEWART-WARNER

GENERAL MOTORS

ROYAL

THE AIR CELL

DELCO

HOW THE WIDE-AWAKE EXPERIMENTER

MODERN QUARTZ-

THE crystal-tuned receiver was introduced to America by RADIO NEWS magazine in the fall of 1930. A series of articles on the Stenode by Dr. Robinson, the inventor of the system, described the theoretical considerations involved in quartz-crystal receiving circuits, but no attempt was made to supply experimenters with constructional data. It was appreciated that the experimental receivers were laboratory rather than production designs; that standardization and additional engineering of special parts was desirable before the receiver could be offered to the public. The receiver, today, emerges from the laboratory a highly practical and efficient receiver. And the perfection of circuit details has been accompanied with the clarification of its theoretical principles.

The introduction of the Stenode principle plate circuit in the i.f. amplifier of a sated audio circuit has already created experimenters. Now a receiver using practical degree and a constructional allow the experimenter to test the system of which this

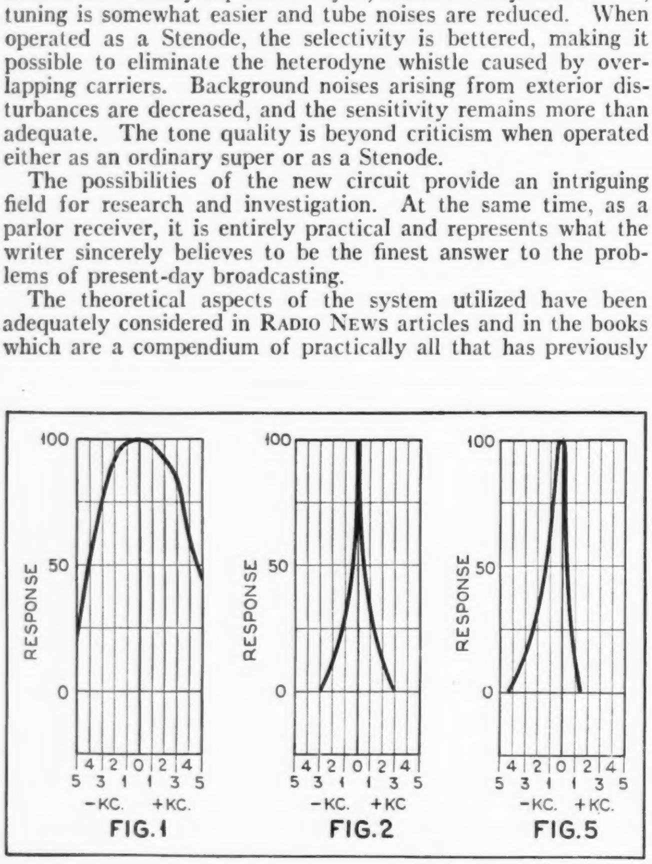
Ordinary "Super," or Stenode

The receiver to be considered in the present series of articles is a modification of the original experimental receiver described in the Stenode books and for which parts have been available since last fall. While the 1932 Stenode represents a considerable improvement over this experimental receiver, the general design is the same and the former receiver may be readily converted into the improved model. Aside from several improvements in the circuit itself, a switch has been provided making it possible to operate the receiver as an ordinary superheterodyne when the peculiar characteristics of the quartz circuit are not essential to enjoyable reception. When operated as an ordinary superheterodyne, the sensitivity is increased, tuning is somewhat easier and tube noises are reduced. When operated as a Stenode, the selectivity is bettered, making it possible to eliminate the heterodyne whistle caused by overlapping carriers. Background noises arising from exterior disturbances are decreased, and the sensitivity remains more than adequate. The tone quality is beyond criticism when operated either as an ordinary super or as a Stenode.

The possibilities of the new circuit provide an intriguing field for research and investigation. At the same time, as a parlor receiver, it is entirely practical and represents what the writer sincerely believes to be the finest answer to the problems of present-day broadcasting.

The theoretical aspects of the system utilized have been adequately considered in RADIO NEWS articles and in the books which are a compendium of practically all that has previously appeared on the circuit. We shall therefore limit ourself to constructional details, with the exception of such theoretical considerations as many benefit by further clarification.

By Zeh
Part

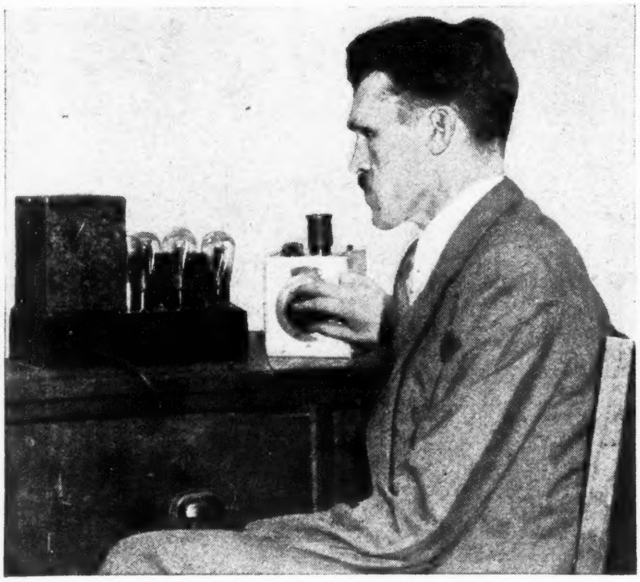


THE OPERATING CHARACTERISTICS

Figure 1. A characteristic response curve of a simple LC circuit. (Figure 2) The sharp response curve of a quartz crystal tuned circuit made under the same conditions as Figure 1. (Figure 5) By unbalancing the crystal circuit this curve is secured, making it possible to tune so sharply on one side or the other of the desired signal that a 2 kc. heterodyne can be eliminated. Compare with Figure 2

The Greeks had a word for it—and in their language "Stenode" means "a narrow pass," which accurately describes the admittance characteristic of the balanced quartz-tuned circuit. The frequency band admitted is narrow indeed—exceeding the sharpness of any other known system by a considerable margin—the selectivity being secured by resonating or tuning with a quartz crystal. Under certain conditions, the resonance characteristics of a simple tuned circuit will plot according to the curve in Figure 1. The resonance curve of a crystal-tuned circuit, under the same conditions, is shown in Figure 2, the extreme selectivity being immediately evident. The crystal circuit is shown at A in Figure 3. The quartz C_r is ground to resonate at the intermediate frequency, 175 kc. S is the secondary of the input intermediate-frequency transformer and is tuned by the usual capacity C_1. C_3 and C_4 are of the same capacity and form the legs of a capacity bridge. C_2 is a balancing condenser. At all frequencies, with the exception of the intermediate frequency of 175 kilocycles, the crystal acts as a small capacity, and the equivalent circuit is shown in B, where R is the input impedance of the tube. With C_2 properly balanced, it is obvious that a bridge condition exists, and no signal across S can be applied to the tube. This balance is maintained even at frequencies very close to 175 kc. However, at the frequency to which the crystal is ground, the impedance of C_r drops practically to zero, the balance no longer exists, and the signal is applied across the input tube. The equivalent circuit now conforms with Diagram C.

MAY TEST THE STENODE PRINCIPLE IN A CRYSTAL RECEIVER



of gaining selectivity by using a quartz-superheterodyne receiver with a compen-wide interest on the part of American this idea has been developed to a highly description of the latest model, which will himself, will be given in a series of articles is the first

Bouck

One

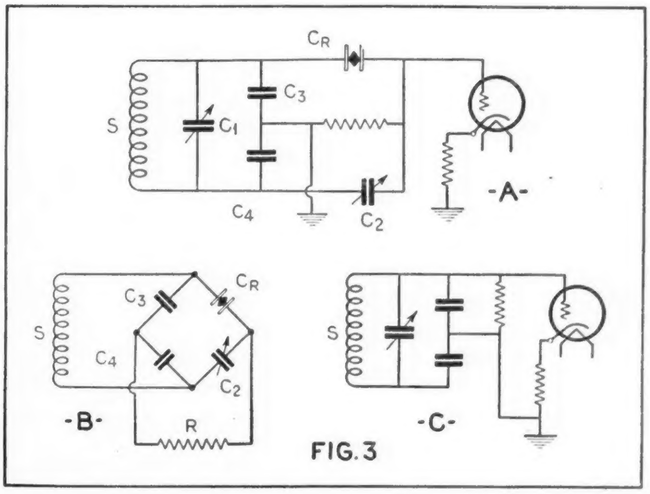
The high degree of signal selectivity of a crystal-tuned circuit, such as that indicated in the curve Figure 2, is admitted without question. However, it is equally evident, in both theory and practice, that the uncorrected output of such a circuit would be almost totally lacking in the higher audio frequencies. A possible system of correction is immediately obvious—*i.e.*, the use of an audio amplifier in which the higher frequencies are favored. The question now is, can this correction be effected without killing the selectivity we have gained through the use of a crystal-tuned circuit? The argument is best illustrated in reference to the curve in Figure 1.

The conventional conception of demodulation declares that the carrier, beating with a side-band, produces a third frequency. The difference between the two, which is of audio frequency, corresponds to the original frequency of modulation. Reference to Figure 1 shows that the response of this particular circuit to a signal 3 kc. off resonance is only about three-fourths the response to the tuned or resonant frequency.: In other words, if the circuit is tuned to 175 kc., a 178 kc. signal, which may either be an interfering signal or the desired carrier, modulated by a 3000-cycle note, will be attenuated to this extent. We are, of course, desirous of weakening an interfering signal. But, as we have also weakened the 3 kc. side-band, the combination of the 178 kc. frequency (representing the desired carrier plus 3 kc. modulation) with the desired 175 kc. carrier will result in an attenuated 3000-cycle note. The result is distortion. However, we may correct this by amplifying 3000 cycles 33.3 percent more than the lower frequencies. However, the beat-note between an interfering carrier at 175 kc. and the desired carrier at 175 kc. is also 3000 cycles which will be equally affected by the correction, and apparently nothing has been gained. In summation, it would appear that we bring up the interference by exactly the same amount we correct the audio loss occasioned by side-band cutting. And this would be the case if all modulation effects could be adequately explained by the ide-band analysis alone.

The Inventor's Explanation

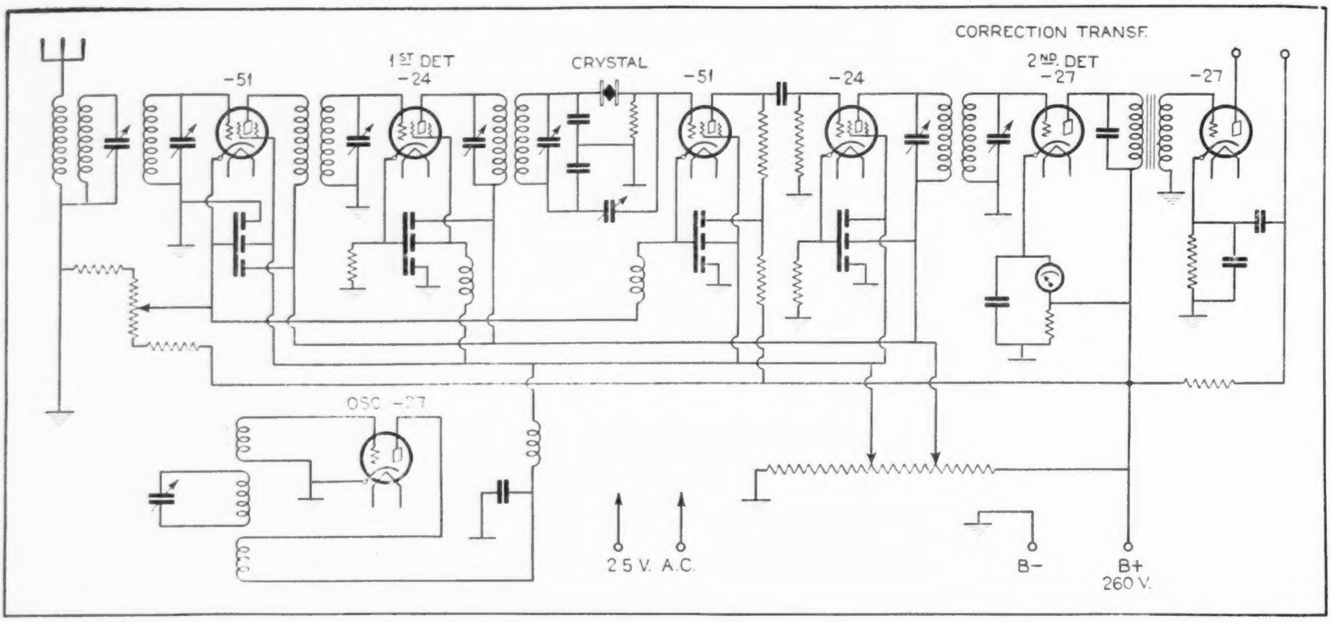
However, several discrepancies, in both theory and observation, result if the possibility of independent amplitude variation of the carrier is not considered in making a final analysis of modulation. This effect may be negligible in dealing with ordinary receivers, but plays an increasingly important part as the tuning circuit is sharpened. All present-day systems of modulation function by means of varying the carrier strength at audio frequencies. An analysis of such modulation by means of the familiar trigonometric expansion will show the radiated wave to be composed of the carrier frequency—plus the side-bands. The simple arithmetic of the problem would indicate that, if the side-bands were trapped out, only the carrier frequency would remain, constant and unvarying in strength, regardless of the fact that it *is* being varied in amplitude many times a second at the modulation frequency. We have here a situation that should be repugnant to common sense—the existence of a carrier constant in amplitude and yet changing in amplitude! Dr. Robinson, appreciating the absurdity, not of the Fourier analysis, but the drawing from it of an unjustifiable conclusion, has revised the conventional trigonometric series so as to include a modulation factor. According to his theory, it would be possible to eliminate the side-bands entirely and admit the carrier only (varying in strength at the modulation frequency), with attenuation, but not total loss, of any frequencies, no matter how high. With such an arrangement, which the Stenode endeavors to approach, no frequencies outside of the carrier frequency would be admitted, and no interference would result, *regardless of the amount of audio correction.* In other words, no trace of 178 kc. signal could get through, to beat with the desired 175 kc. carrier, and the interference would therefore be non-existent, no matter how much it might be necessary to correct the attenuation of the 3000 modulation in the desired carrier.

Another way of looking at the situation is to consider the effects of sharpening a circuit, both from the point of view of



FUNDAMENTALS OF THE CRYSTAL STAGE

Figure 3. (a) The actual input i.f. circuit of the receiver described. (b) The equivalent circuit when balanced and at any frequency other than the crystal frequency. (c) The equivalent circuit at the resonant frequency



THE FUNDAMENTAL CIRCUIT

Figure 6. The exact values of parts and constructional data will follow next month

the conventional side-band analysis and from the point of view of the persistence of oscillation. If, from the side-band standpoint, we sharpen a circuit by lowering the dampening factor (reducing the resistance of the circuit), a certain loss in the high frequencies will accompany a certain reduction in resistance. Similarly, if the presence of modulation frequencies is considered solely a function of amplitude variations in the carrier, the depth of modulation will vary inversely with the frequency, due to the persistence of overlapping effect. It can be shown by mathematics that for a given value of resistance the attenuation of the higher audio frequencies will be exactly the same, whether the calculations are made in reference to the side-band analysis or the persistence theory. When the dampening factor, or resistance, is **zero**, all the side-bands will be cut, and no modulation will exist. Similarly, in a circuit of no resistance, the persistence of oscillations would be constant—it would be impossible for the current to follow any modulation impulses, and the circuit would continue to oscillate, without change of any kind, even if the current were turned off.

Mode of Operation

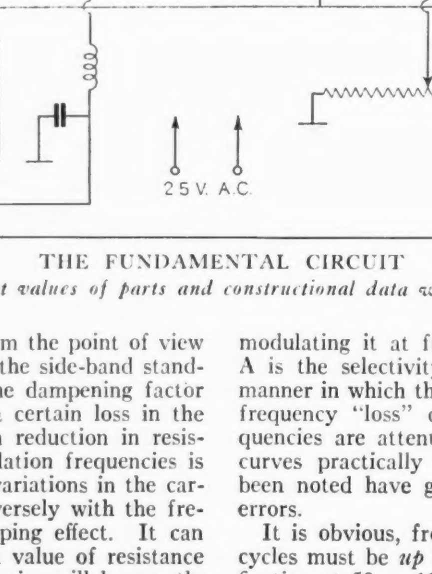
However, the Stenode effect is not a matter of simple reduction in dampening. Due to the mechanico-electrical action of the crystal, it is possible to obtain a degree of selectivity corresponding to very low dampening (sufficient to cause uncontrollable oscillations in a purely electrical circuit) and yet the resistance of the circuit itself is so high that adequate depth of modulation is maintained even at high frequencies.

The percentage modulation in this receiver falls off rapidly from 200 cycles up, the attenuation being almost inversely proportional to frequency. (The design of a correction circuit is therefore not particularly difficult.) The point most worthy of emphasis is the fact that modulation exists in the carrier itself, and though the higher frequencies are greatly attenuated, they can be brought up to normal without commensurate loss in selectivity.

Perhaps the sum total of the arguments is best illustrated in the curves of Figure 4. Curve A is the familiar resonance curve, made by varying the carrier from 170 to 180 kilocycles. Curve B was plotted by maintaining the carrier at 175 kc. and modulating it at frequencies from 50 to 5000 cycles. Curve A is the selectivity curve of the receiver, and indicates the manner in which the side-bands are cut. Curve B is the audio-frequency "loss" curve, showing how the higher audio frequencies are attenuated. On an ordinary receiver, these two curves practically coincide, and such discrepancies as have been noted have generally been passed over as experimental errors.

It is obvious, from curve B, that the amplification at 3000 cycles must be *up* 20 decibels, or ten times that of the amplification at 50 or 100 cycles. This amplification will, in effect, raise curve A by the same amount, and the actual gain in selectivity will be 18 db.—which is a rejection ratio of about **ten to 1.** With the preservation of quality, this is unusually good at 3 kc. off resonance.

By changing the adjustment on the balancing condenser, C2 in Figure 3A, it is possible to distort the resonance curve into the shape shown in Figure 5. While one side is broadened, the slope on the other is almost vertical from the peak, which makes it possible to eliminate heterodyne whistles caused by stations as close as 2 kc. from the desired carrier. Even the whistle from stations 1 kc. off can be reduced to a negligible level. This adjustment is of considerable utility in receiving Canadian and Mexican stations. The U. S. stations are, of course, seldom off frequency enough to necessitate unbalancing, as the selectivity of the Stenode is such that high-pitch heterodynes are eliminated in balanced operation.



THE QUARTZ TUBE

The crystal never burns out. Its life is apparently unlimited, and it is enclosed in vacuum only as a protection against dust

Reducing Background Noise

A by-product of the extreme selectivity of the system is the reduction in outside background noises. Several theories have been advanced to account for this, and while conflicting in respect to the mechanics of reduction, they are in agreement as to results. Roughly, it may be said that the susceptibility of a receiver to radiated disturbances, such as static, is proportional to the area under its resonance curve. In other words, the more broadly a receiver tunes, the higher will be the outside background. Tube noises, however, will be slightly "up" in this receiver when a carrier is tuned in. (The Stenode is absolutely quiet between stations.) This is due to the fact that tube disturbances, beating with the carrier, result in scratching sounds, the amplification (*Continued on page* 878)

PRESENTING

The "Twin-Grid" Tube

A new tube which offers some outstandingly practical advantages is described here by the inventor, who points out a number of its special applications in radio reception and transmission

By **Marion W. Taylor**

Part One

IN presenting the "TWIN-GRID" TUBE, it is the inventor's fondest desire that it shall be found worthy of acceptance on its own merits, and that it shall contribute in a small way to the general usefulness of one of man's greatest benefactors—radio.

—Marion W. Taylor.

THE "twin-grid" tube is, as the name implies, a four-element vacuum tube with duplicate grids. In manner of construction it resembles the well-known three-element electron tube in that it has enclosed in a vacuum a filament for emitting electrons, a plate for attracting and retaining the electrons, and twin or duplicate grids between the plate and filament for controlling the electron stream. These two grid elements have approximately the same electrical and physical characteristics and are insulated from each other so that they may be made to act separately and independently on the electron stream.

Tube Construction

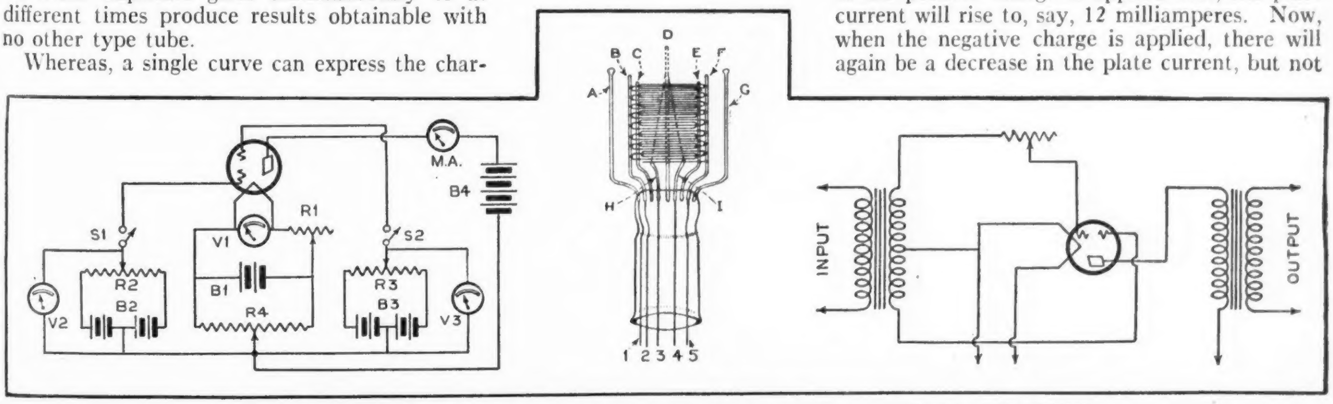
One type of twin-grid tube construction is illustrated in Figure 1, in which one grid element is supported on posts B and E, the other on C and F. Located in the space enclosed by these interlocking grid elements is the filament, supported by posts H, D and I. Posts A and G support the plate element. Leads 1, 2, 3, 4 and 5 from these various elements are brought out to a standard five-prong tube base.

Because of the similarity of the twin-grid and the three-element tube in manner of internal construction and theory of operation, it is naturally assumed that when operating under the same conditions the two tubes will give similar results. Comparison of the characteristic curves of the tubes (Figure 2) will reveal that this assumption is correct. The twin-grid tube, however, offers distinct advantages over other type tubes because of the flexible control of the electron stream made possible by the addition of the second grid element. Combinations of various grid-biasing currents of radio or audio frequency, or both, induced on these duplicate grids simultaneously or at different times produce results obtainable with no other type tube.

Whereas, a single curve can express the characteristics of three-element tubes as regards the ratio of grid voltage to plate current (filament temperature and plate voltage remaining constant), three curves are required to express the same ratio in twin-grid tubes, inasmuch as the electron stream may be acted upon by any or all of these different grid potentials which may exist within the tube at the same time.

A typical set of characteristic curves is shown in Figure 2. Curve A expresses the grid voltage-plate current ratio of one of the duplicate grids taken separately. (Since the two grid elements have the same electrical and physical characteristics, identical curves will be obtained from either grid). Curve B shows the effect of the two grids acting in parallel, and may be obtained by two methods: The two elements may be connected together and supplied by the same biasing battery, or they may be connected separately to individual batteries of the same voltage and polarity. In either method the curves obtained will be identical. Curve C is obtained by inducing equal charges of opposite polarity on the two grids simultaneously, thereby neutralizing the total grid charge. It will be noted, however, that these charges neutralize only so long as they are of a relatively low potential. As the voltages of the grid charges are increased, the balance effect will decrease in favor of the negative charge. For example, when a current of 10 milliamperes is flowing in the plate circuit of a tube under test, and a negative grid bias of, say, 10 volts is induced on one grid, the plate current will fall to about 6 milliamperes. Now, if a positive bias of 10 volts is induced on the other grid, the two charges will completely neutralize, and the plate current will return to 10 milliamperes.

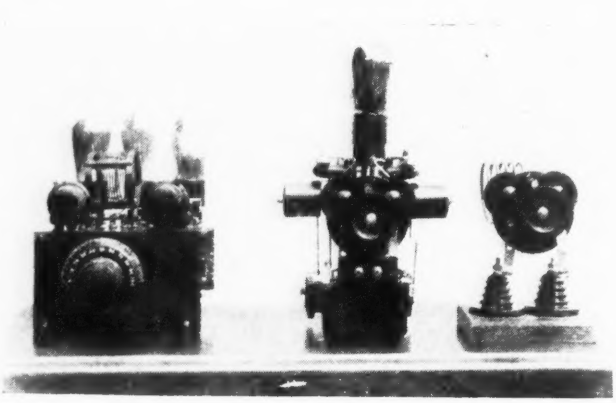
If the positive charge is applied first, the plate current will rise to, say, 12 milliamperes. Now, when the negative charge is applied, there will again be a decrease in the plate current, but not



MEASUREMENT CIRCUIT CONSTRUCTION VOLUME CONTROL CIRCUITS

Figure 1 (center). The two grids are so placed as to be in identical relationship to the filament. Figure 3 (left). This is the circuit employed in plotting the characteristic curves shown in Figure 2. Figure 5 (right). This shows how advantage is taken of the reversed grid potential balance principle to provide automatic volume control

a decrease of 4 milliamperes as before, which would bring the plate current to 8 milliamperes. Instead, the two charges simply neutralize, and a decrease of only 2 milliamperes occurs, the plate current again returning to the normal 10 milliampere reading. Now, if the two charges are increased to 25 volts and the negative charge is applied, the plate current will drop to, say, 2 milliamperes. Upon application of the positive charge upon the duplicate grid, the plate current will rise to about 7 milliamperes. If the positive charge be applied first, the plate current will rise to about 14 milliamperes. Then, when the negative charge is applied, the current will again fall to 7 milliamperes. This unbalanced action in favor of the negative charge is due to the fact that the higher voltage tends to bring the space charge within the tube to the near negative saturation point. Therefore, when using the tube in a balanced circuit, it is essential that the charge in the grid circuits be maintained at a relatively low potential.



USING THE NEW TUBES

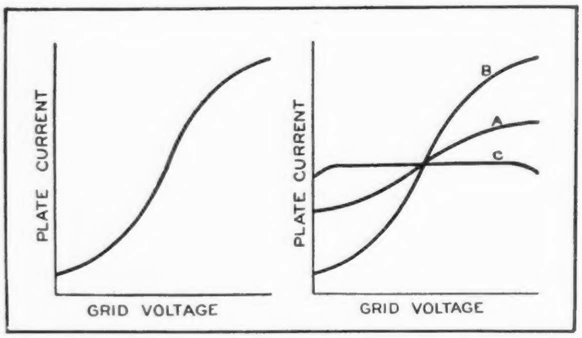
At the left is a short-wave receiver. Center, an amateur 'phone transmitter in which the single twin-grid tube serves as both oscillator and modulator

A suitable circuit for plotting the characteristic curves of the twin-grid tube is illustrated in Figure 3. The circuit is fundamentally the same as that used for plotting the curve of a three-element tube with the addition of suitable apparatus incorporated within the circuit to supply a variable-grid biasing current to the additional grid. The values indicated are for plotting the curves of a receiving type tube as illustrated in Figure 1. Suitable values may be substituted for other types.

The term "reversed grid potential balance" may be applied to any twin-grid tube circuit in which the plate-to-filament current flow within the tube is maintained at a given value by counteracting any current change in one grid circuit by inducing simultaneously a similar current change of reversed order in the other grid circuit.

For example, let it be assumed that a twin-grid tube is functioning as an amplifier, and that a certain current of x frequency is induced in one grid circuit as represented by wave train x in diagram A of Figure 4. This x current in the grid circuit acting upon the electron stream will produce y pulsations in the plate circuit as represented by wave train y. Inasmuch as there is no current in the duplicate grid circuit, its curve is a straight line coinciding with the grid time axis. Action thus far in the tube is exactly the same as occurs in the three-element type tube. Now, with the tube operating as explained before, induce at half the value another current of x frequency in the duplicate grid circuit at opposite phase relation to the first current as indicated by wave train x^1 in diagram B. These two opposing currents acting on the electron stream will again produce y pulsations in the plate circuit, but it will be noted that these pulsations have decreased to about one-half their original value, due to the balancing or neutralizing effect of the opposing grid charges.

Now, if the value of grid current x^1 be increased until it exactly equals that of grid current x, as shown in diagram C, the currents operating with equal force on the electron stream will completely neutralize, the y pulsations in the plate circuit falling to zero amplitude, its curve being a straight line coinciding with the time axis. It follows, therefore, that in any twin-grid tube circuit in which two grid charges are acting in opposite phase or at reversed polarity, the plate-current amplitude is directly proportional to the difference of the grid potentials applied to the new tube.

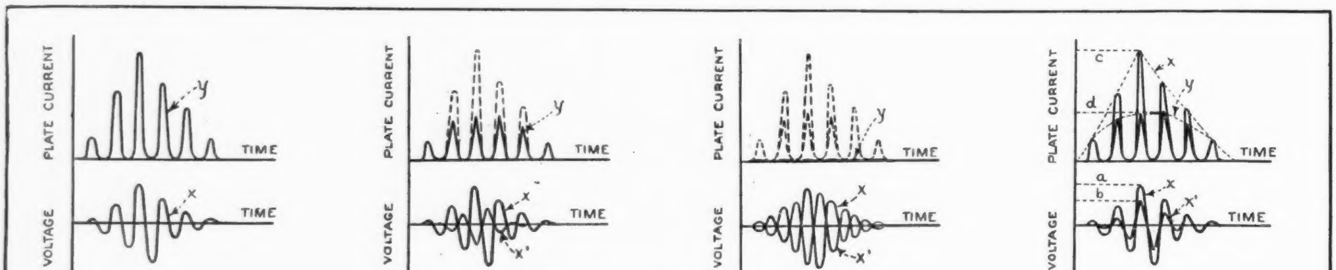


CHARACTERISTIC CURVES

Figure 2. At the left is a typical curve of a three-element tube. At the right are the three curves representing the characteristics of the new tube. Curve A is obtained when using either grid alone. Curve B results when the two grids are connected in parallel. Curve C shows complete neutralization resulting when voltages of unlike polarity or of opposite phase are impressed on the two grids

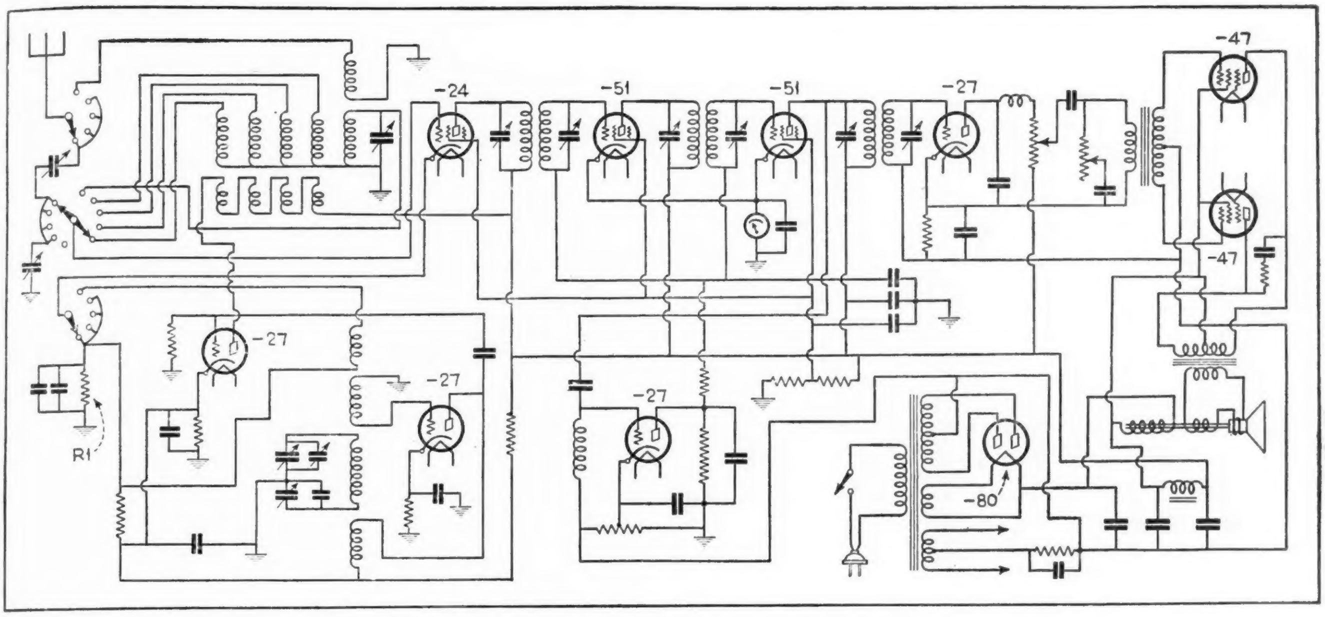
Automatic Volume Control

How this grid potential plate-current ratio may be utilized in an automatic volume control is illustrated in diagram D of Figure 4. Here it will be seen that when the signal x of (a) amplitude is induced on one grid circuit, it produces y pulsations of (c) amplitude in the plate circuit. Now when the opposing current x^1 of b) amplitude is induced at opposite phase on the other grid circuit, the y pulsations in the plate circuit decrease to (d) amplitude. As pointed out before, if the value of x^1 be increased until it exactly equals that of x, the y pulsations will drop to zero amplitude. Therefore, it will be seen that the y pulsations in the plate circuit of amplitude (d) is the result of (*Cont'd on page* 888)



REVERSED GRID POTENTIAL BALANCE

Figure 4. By applying equal voltages of opposite polarity to the two grids, they cancel each other out completely. Unequal voltages will effect a partial cancellation, the amplitude of the plate current being proportional to the difference between the grid voltages



SCHEMATIC DIAGRAM OF THE COMPLETE MULTIPLE-WAVE HOOKUP

Figure 5. At the extreme left are the circuit-changing switches with the various wave-changing coils, followed by the detector, intermediate frequency amplifier, second detector and pentode push-pull output. Below are the two –27 tubes in the new oscillator circuit, followed by the automatic volume control and the rectifier and power circuits

A 16.5 TO 550 METER ALL-WAVE "SUPER" OF

Radical Circuit Design

Here is a new circuit design for multiple band reception that should be mighty interesting to all radio circuit experimenters. It contains a radical oscillator, complex at first sight, but worked out with remarkable simplicity

By McMurdo Silver*

WHEN the 10 to 550-meter superheterodyne was described in the August, 1931, issue of RADIO NEWS it represented the latest word in short-wave and broadcast receiver design. Today many thousands of these sets are giving satisfaction in almost every country in the world. Nevertheless, despite its relative simplicity in terms of simplicity versus performance, it was not as simple as could be desired, but unfortunately no means were known which would permit of a simpler coil-selecting arrangement for the short-wave bands, or which would permit elimination of certain unpleasant, but not really detrimental sounds which occurred as the short-wave dial was tuned because of some unavoidable reaction between harmonics of the broadcast band and short-wave oscillators.

In November, 1930, during the course of development work on an extremely cheap short-wave superheterodyne for export trade, some experimenting was done with autodyne first detectors for the sake of simplicity and low cost, and while nothing satisfactory resulted, an idea was found by Kendall Clough, which now, fully worked out, bids fair to be one of the greatest contributions to short-wave receiver design. At one stroke it simplifies the tuning of short-wave superheterodynes, eliminates two-thirds of the switching necessary in sets not employing plug-in coils and does away with all noises on short waves, due to oscillator reactions.

While the autodyne detector system at first glance appears attractive, it has two drawbacks which, in our opinion, render it completely useless in a "superhet." The first is its inability to discriminate against image-frequency interference, since every signal is impressed directly on the one tuned circuit of the combined oscillator-detector tube. The second drawback is that, since this circuit must be tuned away from the signal frequency by the amount of the intermediate frequency to produce the necessary heterodyning action, and as on short waves this i.f. may be quite high, much loss of signal voltage results, particularly on the lower signal frequencies. Nevertheless, the autodyne action is quite simple. The new Clough system is equally simple, yet has none of the autodyne's drawbacks, and is in no sense related to the autodyne system, since it employs a separate

THE COMPLETE RECEIVER WITH LOUDSPEAKER

Figure 2. Note the simplicity of this entirely new ten-tube superheterodyne. The tuning meter is mounted on a bracket, but in the finished model it is located directly over the tuning dial at center

*President
Silver-Marshall, Inc.

and distinct detector and oscillator with their separate tuned circuits.

The idea is ridiculously simple, as practically all ideas approaching the revolutionary category always are. But its practical realization involved much burning of the midnight oil in terms of study of the problems involved and experimentation to solve them. Briefly, the idea is to use only one oscillator in the set, which must tune from 16.5 to 550 meters, or 18,000 to 550 kc. Offhand, this sounds impossible, and it is, for even the harmonics of the oscillator are too weak to be of direct use. The crux of the idea lies in the use of a tube directly coupled to the oscillator, which is so set as to tune over the broadcast band of 550 to 1500 kc., this tube acting as a harmonic generator and providing the necessary local frequencies to heterodyne signals in the 16 to 35, 35 to 65, 65 to 100 and 100 to 200-meter short-wave bands. This system results in only one permanently connected and aligned oscillator circuit, the harmonic generator tube providing the required heterodyne voltages for the short-wave bands. A single selector-switch knob gives a choice of five separate coils to enable the first detector to cover the four short-wave and the broadcast bands. In the final embodiment, one dial tunes the broadcast band, this same dial, plus an auxiliary trimmer, tunes the short-wave bands, and one five-position switch selects the five bands at will.

Before describing the features of the system, it may be well to allay skepticism by stating that the receiver illustrated and described herewith embodying this new system shows a broadcast sensitivity on the order of two to three microvolts input for standard output, and 10 kc. selectivity with minimum image frequency or cross-talk interference, a fidelity curve from antenna to ear flat to a few decibels from 40 to 4000 cycles, and five to six watts of undistorted power output.

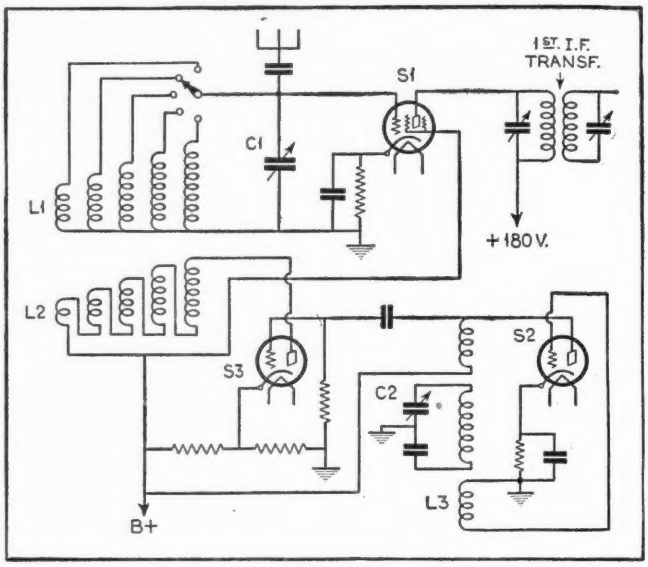
Outstanding Features of Circuit

It is difficult to present the salient points simply and concisely, for they are many and inter-related. For example, one of the first is the choice of intermediate amplification frequency. Since only one is used, it must be selected carefully with respect to both broadcast band and short-wave operation. The ideal broadcast band intermediate frequency of 175 kc. is almost worthless below 200 meters, and the next logical step is to 465 kc., which gives the advantage of "one-shot" operation over all but 2% of the broadcast band (1480 to 1500 kc.), as well as being satisfactory for short-wave reception. A frequency of 465 kc. for the i.f. simplifies image-frequency interference in the broadcast band to a point where it can be handled nicely by one high-Q tuned circuit ahead of the first detector, as compared to the two tuned circuits invariably needed with a 175 kc. i.f. amplifier. This is a considerable gain in simplicity, but brings in another problem, that of i.f. harmonic feedback from the second or audio detector, which will appear at multitples of the intermediate frequency, or 930 and 1395 kc. By careful arrangement of parts and filtration, this can be eliminated, and no "tweets" will be apparent on the broadcast dial at these frequencies.

The arithmetical selectivity throughout the 550 to 1550 kc. broadcast band is not as high as might be desired, but it is adequate with the improved engineering technique of i.f. amplification available today, and it is very good on the short waves.

The Harmonic Generator

In the circuit of Figure 1 is shown a simplified example of the harmonic generator arrangement used to produce the short-wave heterodyne frequencies. S1 is the –24 screen-grid first detector tube, with its tuned input circuit represented by five coils, all designated L1, selected by the five-point switch to cover the five different bands and tuned by the condenser C1.

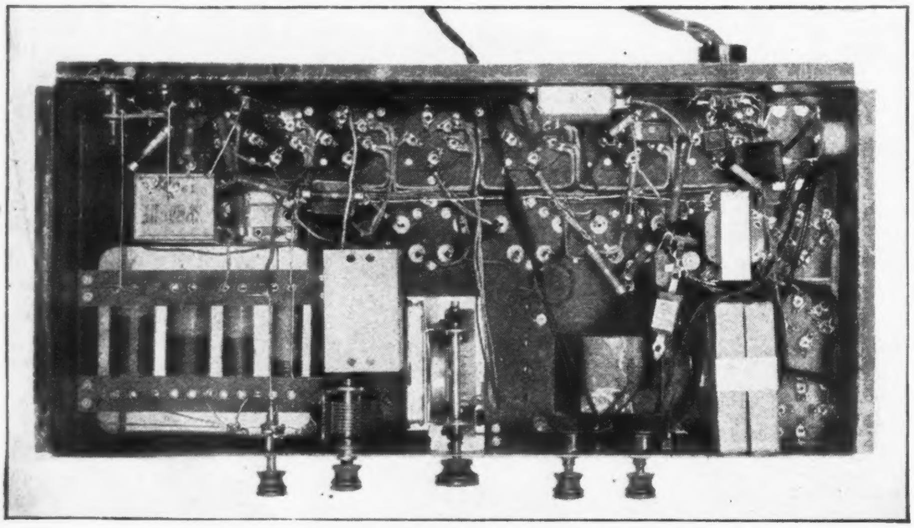


THE BASIC CIRCUIT EMPLOYED

Figure 1. Here is shown the connections for the new Clough first detector, oscillator and harmonic generator for the short-wave and broadcast bands

S2 is the oscillator tube, L3 representing its plate, tank tuning and grid coils. S3 is the harmonic generator tube, across the plate coils of which, L2, is developed the required short-wave heterodyne voltages, the coils L2 each being properly coupled to the short-wave coils L1.

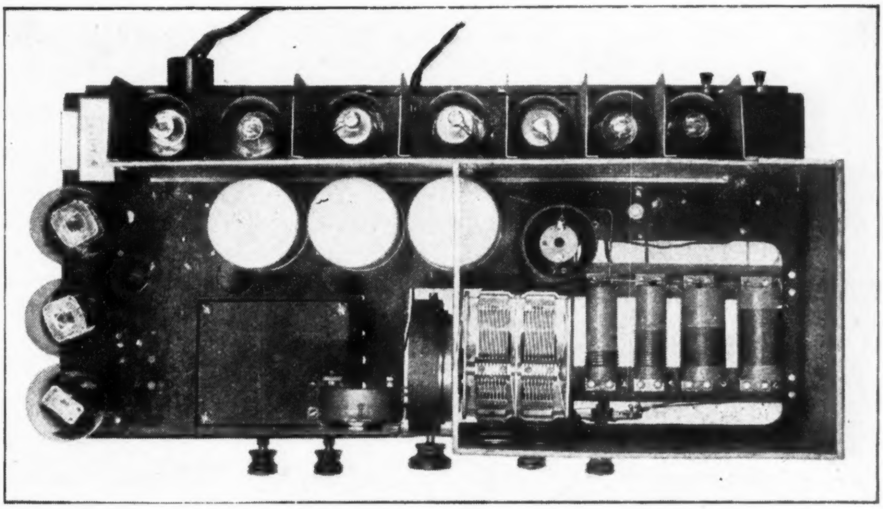
In operation, one set of L1 coils covers the band of 550 to 1500 kc., and the fundamental oscillator range is therefore the sum of these limit frequencies plus the i.f. of 465 kc., or 1015 to 1965 kc. The oscillator is coupled to this L1 coil (not shown in the diagram of Figure 1 for simplicity) and serves to heterodyne all broadcast signals to 465 kc. for the i.f. amplifier. When so used the harmonic-generator tube S3 is not utilized. If the band-selector switch is now turned to the second L1 coil, the useful tuning range of the first detector will be about 90 to 200 meters, and the oscillator is obviously useless to heterodyne signals in this range to 465 kc. But now the harmonic-generator tube S3 *is* utilized, and its grid circuit, directly coupled to the oscillator plate circuit, is fed frequencies in the range of 1015 to 1965 kc. by the oscillator. S3 is biased well below its cut-off point so it draws no plate current when not fed by the oscillator, and acts as a rectifier, or more properly, as a frequency multiplier. In its plate circuit, therefore, will appear multiples of the oscillator frequency, or harmonics which will be progressively weaker as the harmonics increase.



VIEW FROM THE UNDERSIDE

Figure 4. The apparatus and connections underneath the receiver with the bottom shield removed. This photograph was made from the laboratory model

If we consider the second harmonic of the oscillator, it will be seen to be 2030 to 3930 kc., from which we must subtract the 465 kc. i.f. to find what signal frequencies it will satisfactorily heterodyne in this set. We find that this range will be 1565 to 3465 kc., or from just below 200 meters to about 87 meters (there is obviously a gap of 65 kc. between the broadcast band and the 90 to 200-meter band, but actually there is no such gap, because the oscillator covers a range sufficiently wider than 550 to 1500 kc. to eliminate it, but the gap is allowed to appear in this explanation as though it existed in order to phrase the explanation in familiar frequency terms. Actually there is an overlap at the 200-meter points, though not as great as some of the really excessive overlaps on the higher frequency tuning ranges.



TOP VIEW OF CHASSIS, SHIELD REMOVED

Figure 3. This illustration shows short-wave coils exposed for inspection with the various tubes in view in their various shielded compartments

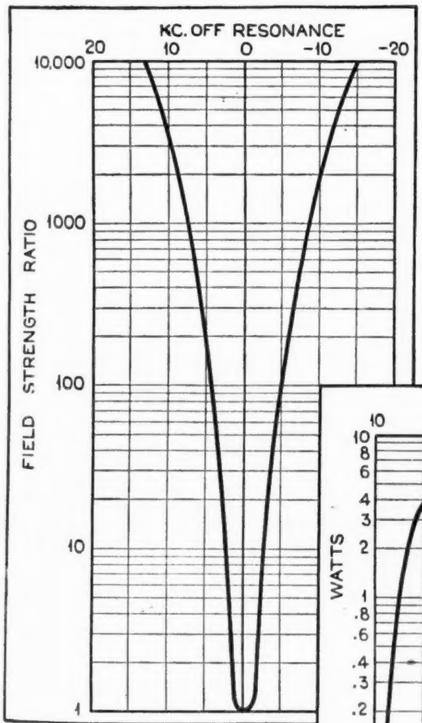
As in all rectifiers, little of the fundamental oscillator frequency gets through tube S3, but even if it did, it is of little importance. Likewise, the higher harmonics, though stronger, are of no importance, due to the high effective selectivity of the first detector circuit.

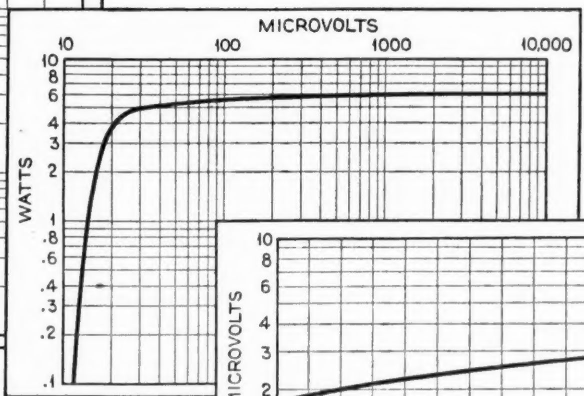
The third harmonic of the oscillator covers the range of 3045 to 5895 kc., from which the i.f. of 465 kc. is subtracted to find the actual signal tuning range, which is 2580 to 5430 kc., or 116 to 55 meters approximately. This third oscillator range, or third harmonic range, is utilized by the third first-detector tuning coil.

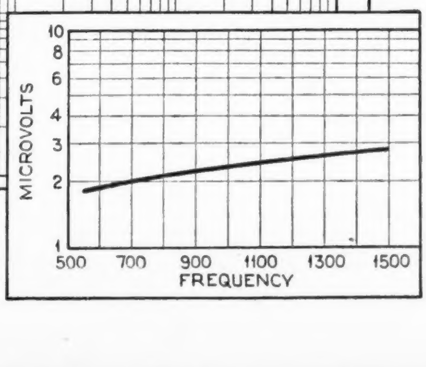
From this explanation it is apparent that the last two ranges are covered by the fifth and ninth oscillator harmonics generated by tube S3, and without individually analyzing them it may be stated that they are from approximately 65 to 32.5 and 34.5 to 17.5 meters, with large overlaps between bands. (In the last case, the use of the second possible oscillator heterodyne frequency extends the range to 16.5 meters.)

In the actual receiver illustrated herewith, the basic circuit of Figure 1 has been deviated from only to the extent necessary for constructional reasons, such as the method of changing antenna connections from broadcast to short-wave bands, etc.

One of the advantages of the system is that the tuning dial can be divided into five accurately calibrated sections, making the finding of stations quite easy. This calibration is quite accurate, sufficient to enable easy hunting—in a narrow range—for a new station, since once the dial is set to the range indicated by the selector switch it is only necessary to adjust the trimmer knob for greatest volume to obtain resonance when hunting is done by adjusting both knobs simultaneously. Once found, the logging of the oscillator dial, which is quite sharp, while the antenna tuning knob is not nearly so sharp, is absolutely dependable, and stations will always be found at the same dial setting. While the selectivity on all-wave is 10 kc., the short-wave tuning is delightfully smooth, easy and simple as compared to some earlier short-wave superheterodynes.







THREE CURVES THAT TELL A STORY

Figure 7, left, is the selectivity curve at 1400 kc. Figure 8, center, shows power output in undistorted watts. Figure 6, right, shows broadcast sensitivity with output of 50 milliwatts

Harmonic Equalization

It is a well-known fact that the amplitudes of successive harmonics developed by an oscillator or harmonic generator fall off as the harmonics increase, and the question will arise as to how, in this system, the ninth harmonic can be strong enough to do a good heterodyning job, since it is much weaker than the second harmonic. The answer is simple. In terms of percentage, the resonance curves of all four first-detector short-wave circuits are substantially the same, while the distance away from resonance of these circuits that the oscillator must work is constant at 465 kc. This means that the percentage difference decreases with increasing frequency, or that the harmonic generator sees an increasing impedance in the first detector circuit, across which it must develop the heterodyne voltage, as the frequency increases. The net result is a practical balance, whereby as the used harmonics step up and decrease in amplitude, their task is made correspondingly simpler. In actual practice, therefore, the decrease in amplitude of successive harmonics is compensated for so that it is of no practical consequence.

Much has been said in favor of automatic volume control in radio receivers to eliminate the effects of fading, and there is some justification for it on short-wave receivers, but it must be borne in mind that it is no panacea for all fading troubles. To begin with, of all the so-called automatic volume controls found on commercial broadcast receivers today, only one has been anywhere near true automatic volume control—and that example has been obsolete for a year and a half or more. Such "automatic volume controls" as are found today are "blast eliminators" only, for they will not hold power output constant for normally wide variations of signal voltage, as is the prime requisite of automatic (*Continued on page* 881)

THE RADIO NEWS EAR AID PROVES A BOON TO THE DEAF

Reports from readers concerning the* RADIO NEWS *Ear Aid indicate its unusual effectiveness in overcoming the handicap of deafness. It is also providing a source of real profit for servicemen who are specializing in this work

By S. Gordon Taylor

AFTER the RADIO NEWS Ear Aid was designed, but before its description was published, RADIO NEWS tested it extensively among hard-of-hearing people. The results of these tests indicated that the Ear Aid was a surprisingly effective device. However, to provide a double check, letters have recently been written to several individuals and servicemen who were known to have constructed the Ear Aid following the publication of the descriptive article. The purpose of these inquiries was to determine whether the Ear Aid had come up to expectations and also to obtain any comments which the makers cared to offer. These inquiries went to about a dozen people, all told, some of whom were servicemen and others individuals who had constructed the unit for their own use.

The responses to these inquiries has been most gratifying. One dealer (who personally called on the author) stated that of ten persons to whom he had demonstrated the Ear Aid, he made sales to eight. This was accomplished within thirty days after he read the constructional article in the January issue.

Some of the written comments from other builders will be of interest. The following quotations are published without the names of the writers because time does not permit writing to them to obtain their permission to use their names. However, RADIO NEWS will be glad to provide the names on request.

One serviceman in Ogden, Utah, has the following to say:

"In reply to your request for a report on the operation of the RADIO NEWS *Ear Aid that I recently constructed, I wish to state that it came entirely up to my expectations. I constructed the instrument for a lady seventy-nine years old who has spent several hundred dollars on hearing devices of various kinds. The last instrument she purchased cost $179.00. The* RADIO NEWS *Ear Aid is the first instrument that has enabled her to hear conversation carried on in normal tones. Recently at a business meeting she used the Aid and was able to hear voices of the eight people in the room very distinctly.*

"The RADIO NEWS *Ear Aid should certainly be a profitable item for servicemen to handle as a side line because of its superior performance, low selling cost and margin of profit. The principle of amplification employed in this instrument is a distinct step forward in assisting those people who are hard of hearing."*

A retail drug concern in Michigan sees in the RADIO NEWS Ear Aid a profitable item which they can logically merchandise. He writes:

"In reply to yours of January 18th, wish to state that the RADIO NEWS *Ear Aid that we made up as per instructions works remarkably well. We have shown this to two or three people and they are very pleased with the outfit; in fact, one man bought one and we have ordered parts to make up a couple more."*

Another reader who lives in Michigan has apparently found the Ear Aid extremely helpful for his own use. He writes:

"I have just received your letter of January 18th, in which you ask for a report covering the building of the RADIO NEWS *Ear Aid. I have just finished one of these devices, and the least I can say about it is that it's a wonder. It more than came up to expectations. I have been a reader of* RADIO NEWS *for a great many years, being one of the early radio 'nuts' as far back as 1920, and I have yet to build anything taken from* RADIO NEWS *that gave me as much pleasure and was of such real value as the Ear Aid."*

A well-known attorney in Cleveland has heretofore had difficulty in hearing the testimony of witnesses in open court. Through the use of the Ear Aid he has been able to overcome this difficulty—but let his letter speak for itself:

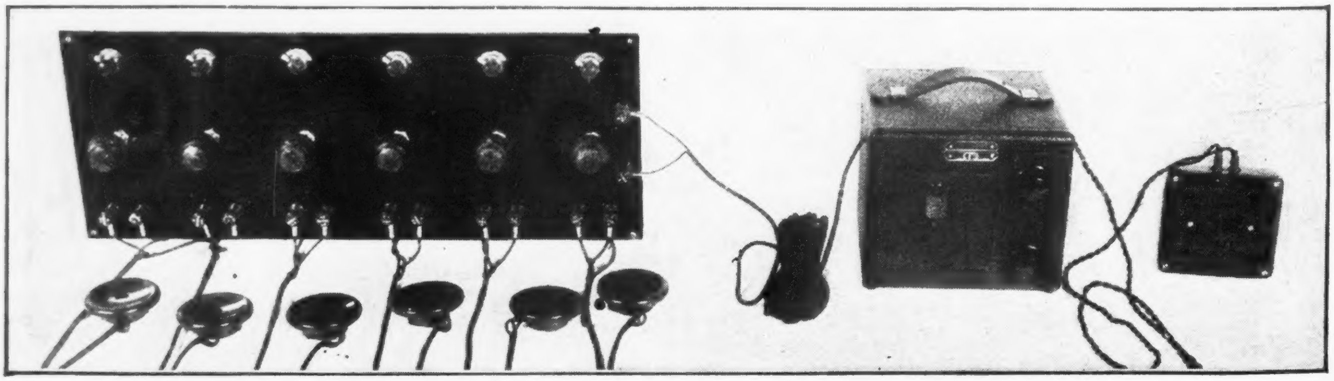
"The two Ear Aids I purchased were for myself, and since that time I have ordered two more of them. I am not only

The New Group Hearing Aid

AS it was impossible to complete the technical development work on the group hearing-aid equipment in time to publish the constructional details in this issue as announced last month, publication has been put off until the May issue. This provides ample time to permit exhaustive tests under actual operating conditions in churches, schools and other meeting places. Such tests are considered essential in perfecting its development. As a result readers may be assured of the utmost in effectiveness in this equipment, at a most moderate cost.

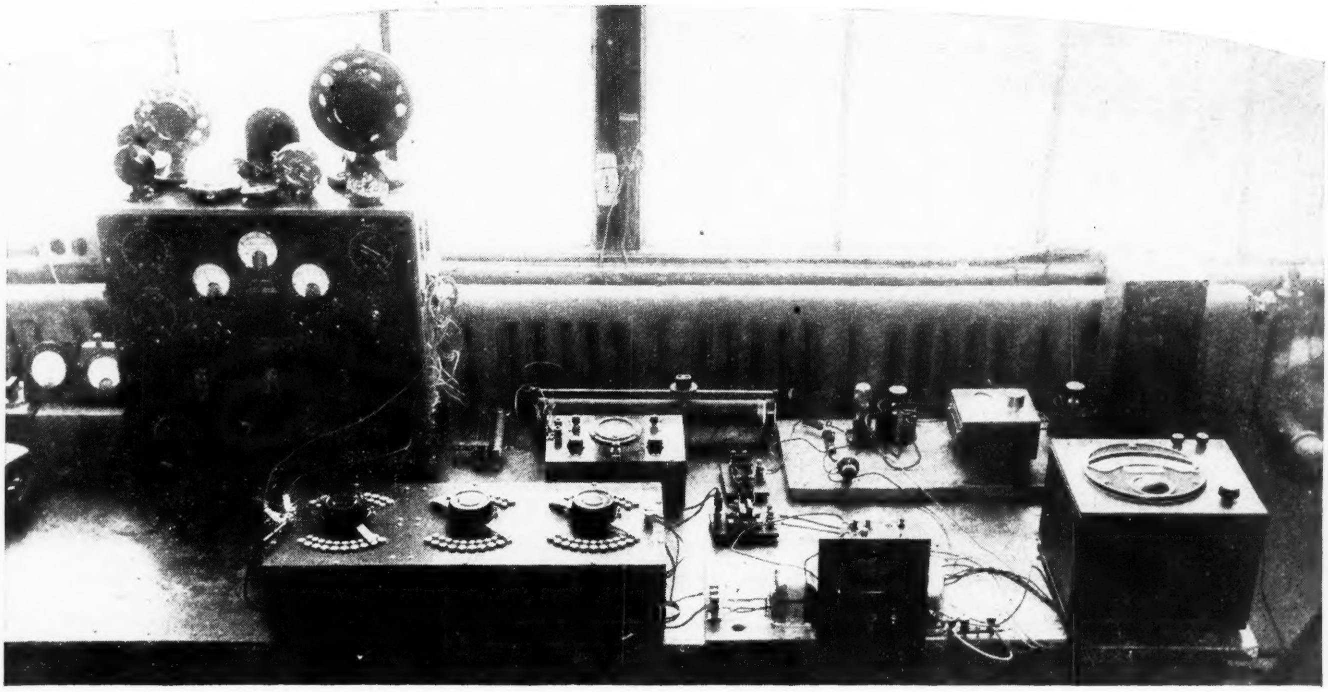
The present article includes, among other things, instructions for using the Ear Aid as a group device. For small groups it is highly effective—just how effective is clearly shown in the text.

—The Editors.



COMPLETE EQUIPMENT FOR A SIX-HEADPHONE GROUP INSTALLATION

This is the set-up used in testing the effectiveness of the Ear Aid for group use. In an actual installation, the six volume controls would be mounted in individual outlet boxes, instead of all on one panel, as shown here



LABORATORY SET-UP USED IN HEARING AID DESIGN WORK

This set-up is the one employed in plotting amplifier characteristics. In this particular case, measurements are being made on a preliminary model of the group hearing equipment to be described next month

using this device myself, but I am also supplying it to others. I happen to be an attorney, but radio and things of that kind are a hobby and sideline with me.

"I am personally delighted with the instrument. I have already used it in an argument in open court, as well as during the taking of testimony in a fairly large room with a number of people present, and I also use it at conferences in my own office, where I have built one of the devices into my desk and equipped it with two microphones so that I get wonderful reception.

"Others have also tried it and used it and find it very satisfactory, although I did run into one possible purchaser whose hearing is so far gone that even this device does not give him sufficient amplification to be of use, but I think that his is an unusual case."

The above quotations indicate the general trend of the replies received from all but two of those to whom inquiries were sent and it is of interest that in each of these two cases microphones other than that specified were employed. This fact is important—not that it indicates that other microphones cannot be successfully used with this amplifier, but rather that it indicates that any microphone used must be one of the ultra-sensitive type and must be in good working order. Obviously, if it is an old hearing-aid microphone that has been discarded because it had lost its sensitivenes, it will not work properly in the Ear Aid.

Profitable Prospects for Servicemen

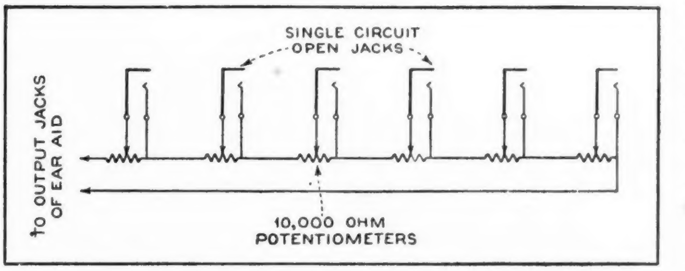
Based on the letters received and other sources of information, it would appear that an unusually high percentage of the prospects to whom the RADIO NEWS Ear Aid is demonstrated are sold on it—marking it as an unusually productive item for the serviceman or radio dealer to handle. The possibilities for business in this field would certainly seem to justify an expenditure, on the part of the serviceman, to cover the cost of parts from which to assemble a demonstration model. The cost of the parts is not high and the margin of profit is ample.

The importance of a demonstration model in going after this business cannot be overestimated. Something over 500 inquiries have been sent in by RADIO NEWS readers since the January article was published, and many of these asked if there was any way of obtaining a local demonstration. In a few cases it has been possible to refer these inquiries to servicemen who had constructed demonstration models, but for the most part there was no way in which demonstrations could be provided.

Register of Demonstration Stations

To assist individuals who desire demonstrations and at the same time to help servicemen and dealers who desire to make and sell this unit, RADIO NEWS hereby extends an invitation to servicemen who have a demonstration model available to send their names and addresses to the author, in care of RADIO NEWS. These names will be placed on file so that future inquiries from readers asking where demonstrations may be obtained can be referred to the nearest servicemen whose names are on our register. In sending in their names, servicemen should also state whether their demonstration models are exactly like that described in the January issue. If any variations have been made, they should be briefly described.

Likewise, any reader who is suffering from defective hearing and is interested in having an Ear Aid made up, but is desirous of first obtaining a demonstration, can write to RADIO NEWS for the address of the nearest dealer or serviceman who can provide a demonstration.



CONNECTIONS FOR GROUP SYSTEM WIRING

Figure 1. Circuit for wiring six headphones with individual volume controls, in the output of the Ear Aid

RADIO NEWS, in offering this special service to servicemen and to individuals, does so with the full conviction that the RADIO NEWS Ear Aid is a device of outstanding merit, and in the hope that by this means its advantages may be made more readily available to those who require such a hearing aid. It is quite understandable that many people who are badly in need of a device of this kind hesitate to spend even the relatively low cost of this unit without first actually trying it to determine whether it meets their requirements. This new RADIO NEWS service will enable them to make this test and at the same time should bring a worthwhile volume of business to servicemen whose names are on file.

(Continued on page 884)

AN INTRODUCTION TO THE VARIOUS PHYSICAL

Phenomena Underlying Radio

Radio apparatus of today, including television, uses practically all of the physical phenomena capable of being controlled by science. Devices which can be assembled within the space of a few cubic feet involve actions and energy transformations ranging over the whole domain of physics. Sound, heat, light, electro-static and electro-magnetic changes, as well as the dynamics of moving parts, are linked together in a chain of interactions which require study if we are to understand them

By E. B. Kirk

Part One

IN the days of "wireless" and crystal detectors we did not have much technical ground to cover. Current electricity, magnetism, electrostatics and electromagnetics sufficed for us to have a fairly intelligent insight into the working of our apparatus. But the vacuum tube and its rapid development opened a new realm and its apparently unlimited versatility has kept us studying ever since. Then the vogue of broadcasting, bringing in the microphone and the loudspeaker, confronted us with the study of sound. Further, the circuits required for the handling of frequencies became much more intricate than those used with our early headphones and code signals. Now, with television stepping on the stage, even more is demanded of us. Electronic effects, known only in the laboratory a few years ago, are in common use. We have to understand optics, piezo-electric devices, light valves, cathode-ray scanning—and this list is increasing daily.

This means that we have to review our physics, brush up on optics, and even if our time does not allow us to read the many technical reports on electronic research, we can, from time to time, study a résumé of the more important items. With this in mind, the present series of articles was planned.

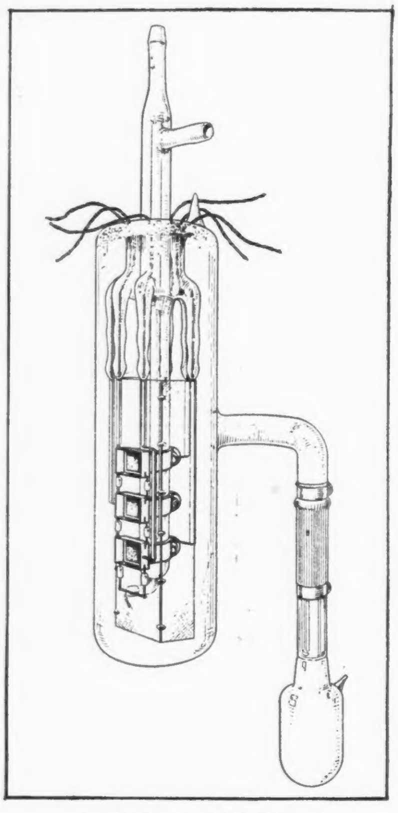
Present Theory Review

For a better correlation of the various fields of physical action, and in order to reduce our explanations to the simplest terms, we can begin with a review of the present theories of matter and energy.

With this as a background we can proceed to the electronic and photo-electric effects, such as the Barkhausen tube and the production of the so-called quasi-optical waves and other effects of interest at the moment. Optics need more than passing attention; the neon tube as a source of light for television and the polarization of light and the means, such as mechanical, electric and magnetic devices, for controlling its action. Next there are a number of magnetic effects which are interesting. Some are being used, for example, magneto-strictive action; others are being worked with and give promise of becoming important. Finally there are certain miscellaneous electrical and chemical phenomena to be touched upon.

The three units with which the physicist attempts to explain all the phenomena of the universe are: the electron, the proton and the photon. The first two of these involve matter and electrical charge, which, of course, is a form of energy; the third deals with energy alone. The electron is the smallest particle of negatively charged matter, and the proton is the smallest particle of positively charged matter. The photon is a unit of radiant energy and is the smallest amount of energy of any particular frequency.

In the above definition of electron and proton we see that matter and electrical charges are tied together and both are reduced to a concept of individual particles. There seems to be no way of getting away from this double definition—of disentangling the two, matter and electricity—for an electrical charge has never been absolutely separated and observed as such, and matter in any of its forms has never been shaken of its ever-attendant electrical properties. If we open an elementary textbook on physics we find that matter is defined as anything which occupies space and which possesses certain properties known to us through our senses. We know from our experience that electricity is a form of energy, that energy is commonly defined as the ability to do work. Modern theory, however, has more to say on these points. The solid atoms of half a century ago which were considered as occupying space, in a literal sense of the word, are now thought of as merely centers of attraction or repulsion, electrical in nature, and an even more radical conception pictures the electron as a group of waves. Light, radiant heat, and radio waves, all of which are forms of energy, have been shown to differ only in their frequency of vibration. Thus slowly the idea that matter and energy are the same, or that they are both expressions of a more fundamental cosmic property, has gained ground; that matter may be transformed into energy and pass off in radiation similar to radio waves, under certain circumstances, and conversely that energy may be converted into matter at some distant point of the universe is accepted by such authorities as Millikan and Jeans.



TRIPLE NEON TUBE

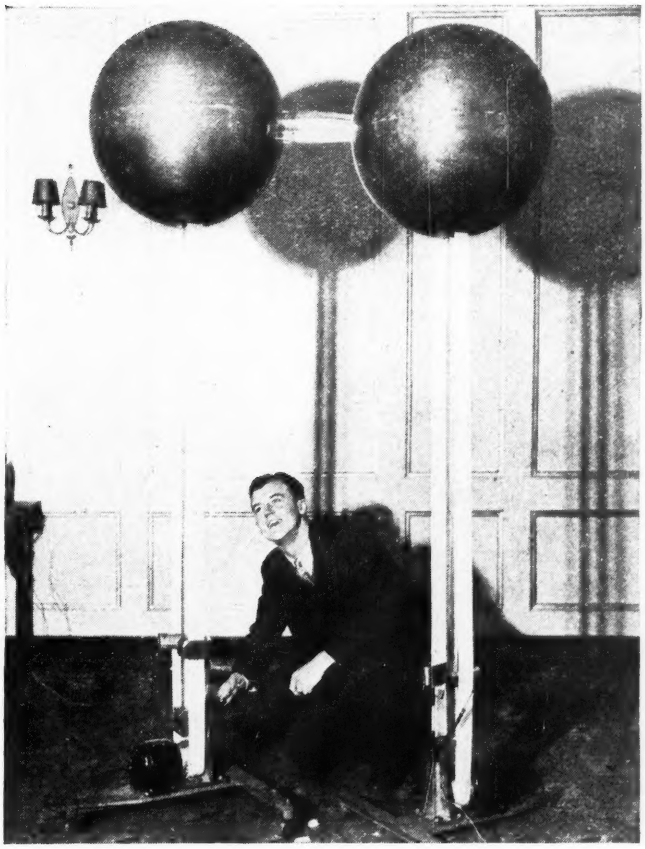
This complicated lamp which is used for television combines the phenomena of ionization and production of light and necessitates an understanding of the Kinetic theory of gases and the science of electronics

The Bohr Atom

We shall have to assume that the reader is familiar, in a general way at least, with the Rutherford-Bohr atom model and that he understands the arrangement of the electrons and protons in the atoms and how the atoms of one element differ from those of another. Let us recall to mind certain details. In the normal state the positive and the negative charges, within the atom, balance each other, leaving the atom electrically

The Old Way and The New

Thompson: Elementary Lessons in Electricity



The old and new ways of producing electricity are illustrated above. At the left is the Electrophorus. A resinous cake is beaten with cat skin and negatively electrified. A metal disk is placed upon it so that it is charged negatively above and positively below. When touched with the finger the negative charge is neutralized and the metal cover may be lifted by the handle and will be found to be charged with high positive potential. In the newer method, as shown at the right, Dr. Vand de Graaf is able to produce over a million volts between two large metal balls by revolving bands of silk with a motor so that frictional charges are built up on each of the balls

neutral. Disturbing forces may result from a change caused by the distribution of the charges in the atom; mechanical impact of atom with atom, or atom with electron; or radiant energy, as a stream of photons, for example, light or X-rays which disturb the inner atomic forces. Some of the planetary electrons are less tightly held in their orbits than others, and therefore a disturbing force may be able to "knock" them entirely out of the atom or to cause them to move to other orbits for a period of time. An atom may also temporarily attract an additional electron. But whenever the normal state is disturbed and there is either an excess or a deficiency of electrons, the condition is unstable and as soon as the disturbing force is removed the atom will tend to assume its normal neutral state with all of its electrical forces balanced. Lastly, since the electron has only 1/1800 of the mass of a proton, practically all of the mass of an atom may be considered as residing in its nucleus, which explains why electrons move at much greater velocity than atoms or ions.

Electron Distribution

So much for the individual atoms. The attractive and repulsive forces which hold the electrons and the protons together, within the atoms, are also used to explain the association of one or more atoms in definite arrangements in the formation of molecules. In such a process electrons may be radically redistributed. The orbits of the electrons of each atom may become interlaced and in certain cases an electron may revolve around two nucleii. In any event, the combination of atoms to form molecules is very complicated and we need not consider the details of the process but only remember that matter in any form, gaseous, liquid or solid, is built up out of atoms and atom groups. In crystals the spacing is very regular, but not necessarily the same in the three dimensions, and in complex molecules (organic compounds) composed of a thousand or so atoms the relation of one atom to another remains the same within certain limits, else the compound breaks down into simpler arrangements.

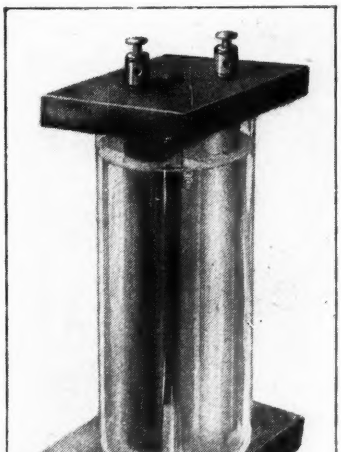


PHOTO-VOLTAIC CELL

This is the Wein cell that produces rather large amounts of electric energy upon being subjected to an application of light

Open Space Between Atoms

In all material, however, there is "open space" between the atoms and molecules which is vast, relative to the sizes of the atoms and electrons. This openness of the structure of solid material is difficult for us to appreciate, for if atomic distances are given in the usual units used to measure them, they mean little to us. A comparison, however, will make these space relations within matter more easily appreciated. Millikan, in his book on the electron, says of its size: . . . "Its radius cannot be larger in comparison with the radius of the atom than is the radius of the earth in comparison with the radius of her orbit about the sun." . . . "The electronic or other constituents of atoms can occupy but an exceedingly small fraction of the space enclosed within the atomic system."

This explains why it is possible for high-speed electrons and even helium atoms to be shot through the glass wall of a highly evacuated tube (*Continued on page* 880)

THE FINISHED MICROPHONE
The size of the microphone can be judged by comparison with the hand

How to Make A

CONDENSER "MIKE"

Amateurs and experimenters have looked on condenser microphones with admiring eyes, but few have been able to indulge the desire for ownership. The author describes one of his own design which can be easily built at home

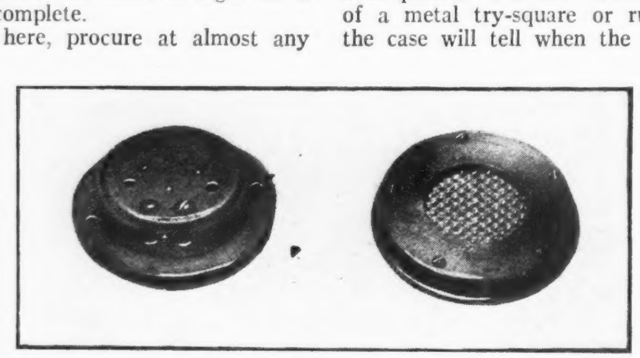
By **George A. Argabrite**

THE electrostatic microphone is undoubtedly the most desirable type of audio pick-up at the present time. Yet, by following a simple procedure and exercising ordinary care, the experimenter can with only the commonest tools build a microphone of this type, the response of which will surprise even the professional.

Operation of the Microphone

First, we will briefly explain the function of an electrostatic microphone. The associated amplifier places a charge on the diaphragm and back plate of the head, air being the dielectric, a low capacity condenser is the result, hence the name "condenser" microphone. Since this condenser is in the grid circuit of the first amplifier it will be seen that a small change in the capacitance of the condenser will vary the grid charge and a similar change will occur in the plate circuit of the first tube, but of greater amplitude. The change in capacity, of course, is caused by acoustic vibrations. If this change in capacitance occurs at audio frequencies a reproducer may be incorporated after the amplification has been brought to a proper level and the circuit is complete.

To build the unit described here, procure at almost any second-hand radio store a type D76841 or 523W Western Electric phonograph horn attachment. The maker's name and type number are plainly stamped on the front or back. Thousands of these units have been sold in years past, so obtaining one ought not prove difficult. The cost will range from twenty-five to fifty cents. Remove the five screws in the face-plate. This, the diaphragm, and phenol gasket will then be free.



FRONT AND REAR VIEW
At left is the rear view of the completed microphone. Right: Front view, showing protective screen

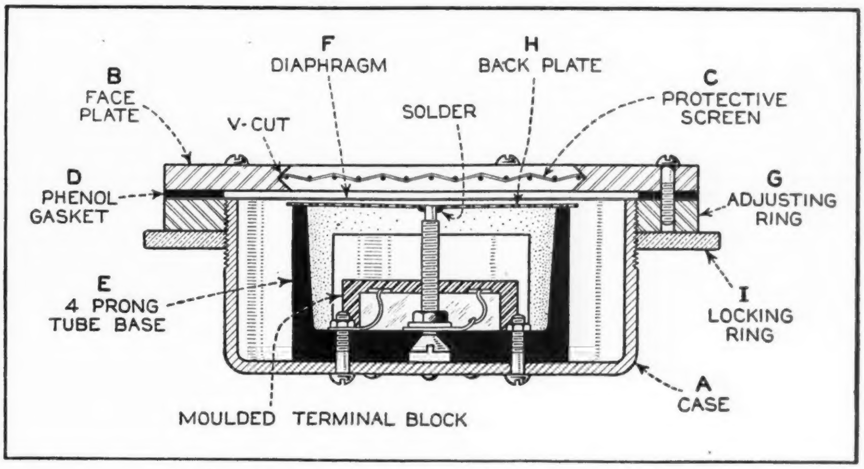
The hole in the center of the face-plate, B, must be enlarged to be about one and five-eighths inches diameter. A "V" cut (see Figure 1) in this plate will accommodate the protective screen, C, which should be one-eighth inch mesh "hardware cloth." This item will cost five or ten cents. Due to the flexibility of the screen, it can easily be made to fit the largest diameter of the "V" cut. Of course, the circle of screen should be cut to this dimension. Any machinist will do the lathe work mentioned for very little, as the time required is not more than fifteen minutes.

The next step is to remove the horseshoe magnet and coils in the receiver. These and the original diaphragm may be discarded, leaving the case as shown in A, Figure 2. Do not remove the molded terminal block which is also in the case, as this is to be used for the terminals in the finished head. A four-prong tube base with prongs removed should now be centered inside the case. It will be necessary to cut away part of the tube base (see E, Figure 2) to accommodate the original terminal block. Do not make the cut any larger than absolutely necessary, as this member should not be weakened.

The tube base should be secured with two machine screws, size 2/56 or 6/32, placed on a diameter parallel to the beforementioned cut. Now cut the upper part of the tube base off with a hack-saw so that its height equals the inside diameter of the case. Mount the tube base in the case as shown in Figure 1, then the plane of the mouth of the tube base and the plane of the mouth of the case are brought together by dressing the whole thing down with fine sandpaper which has been placed on a flat surface. A straight-edge, such as that of a metal try-square or rule, placed across the mouth of the case will tell when the members are in the same plane.

Next cut a one and three-eighths-inch circle of perforated brass sheet, H, gauge No. 25 B. S. (0.0179 in.), perforations to be one-sixteenth inch with about one-thirty-second inch between tangents. A ten-cent piece will be sufficient. Such material may be obtained from any large hardware store, as can the eighth-inch "hardware cloth" mentioned above. When marking the circle on the brass sheet be certain to have one of the perforations in the center. The reason will be seen later. Perforations in this back plate are necessary, as there must be no cushioning effect from the air between it and the diaphragm. If you have the gauge of perforated sheet specified, the next step will be simple. Make six shims of the paper of the inner pages of this magazine and place them between the bottom of the tube base and the inside of the case, thus the bakelite tube base has been raised .0209 of an inch. Again dress the mouth of the tube base down to the plane of the mouth of the case as before. Test with straight-edge.

It will now be necessary to remove the tube base and drill a hole in the center, and counter sink from the bottom to receive a flat-head brass one-inch 6/32 machine screw, the head of which is filed down to the bottom of the screw-driver slot. The head of the screw should be one-sixteenth inch, more or less, from the case so as to keep the unvarying capacity of the instrument to a minimum. The screw should now be bolted upright in the center of the tube base, and the tube base permanently fastened in the back case. A provision should also be made to take a terminal from the center upright screw. This lead may be soldered to one of the terminals of the case, which will be the live lead of the head. Now file the centered screw to the same height as the tube base. Test with a straight-edge. Also file down the threads of the 6/32 screw for about one-eighth inch from the top end. The end of the screw should now fit the center hole of the brass perforated disc previously described. To one of the screws which holds the tube base in the case make a connection to the other terminal of the case. This will be "ground" of the head.



SECTIONAL VIEW OF COMPLETED UNIT

Figure 1. All details of the assembly are shown. Each individual part is shown in Figure 2, the letters representing similar parts in the two illustrations

Preparing the Back Plate

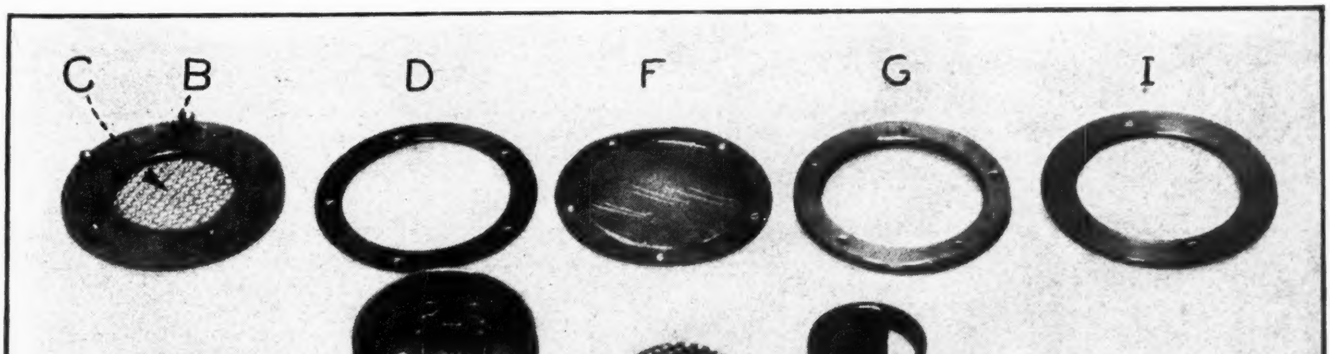
The back plate may now be installed. Carefully file and sandpaper all minute burrs from the circular perforated brass disc and make certain that the disc is flat. Place the disc over the mouth of the tube base, and center so that by slightly depressing the mid portion of the disc the center pin will fit the central hole of the disc. Carefully solder while in this depressed position. Remove all surplus solder. The slight tension against the mouth of the tube base will hold the back plate in the correct position.

The back plate must now be polished down. To the center of a smooth, flat, six-inch square of three-fourths or one-inch wood glue a one and one-half-inch circle of fine sandpaper. Weight down until the glue sets. The back plate may now be dressed down on the circle of sandpaper while the rim of the case will not be touched. Very little of this operation will be necessary. Test with metal straight-edge while the two terminals of the back case are connected in series with a pair of phones and a 22½-volt B battery. Slide the metal straight-edge across the mouth of the back case several times in various directions. No clicks should be heard in the phones. Blow and wipe out all minute particles of metal and sand. There should be no more than enough space between the outer edge of the back plate and the straight-edge to allow a piece of paper of the inner pages of this book to slip easily. At the center of the back plate there should be room enough for two thicknesses of paper. The variations in the thickness of the paper are of the order of one or two ten thousandths, which will not matter.

The installation of the diaphragm now will be the next step. Procure a pack of "Old Gold" cigarettes, carefully remove the tinfoil and straighten out on a smooth, flat surface. A small piece of wadded-up cloth is best. For anyone who might object to using tinfoil for a diaphragm, let us say that after having used both tinfoil and special diaphragm dural for this unit, the response curves when plotted showed so little difference as not to be distinguishable by ear. Also the tinfoil is uniformly less than a thousandth of an inch thick, is of a proper crinkly hardness, and is easily obtained. However, any tinfoil will not do—use only the cigarette foil specified and play safe.

Adjusting the Diaphragm

The diaphragm, F, should now be placed in position between the phenol gasket, D, and the threaded adjusting ring, G, which receives the five clamping screws. Of course, the diaphragm should be reasonably flat and smooth before it is placed in position for clamping. It will not be necessary to make holes in the foil. Be certain to have the diaphragm very securely clamped. Go over the five screws several times, tightening a little each round. It will be seen that the diaphragm stretching-process can easily be accomplished by virtue of the fiber gasket and threaded back case. When the back case is screwed into the adjusting ring it will push the diaphragm forward and thus stretch it. (*Continued on page* 879)



THE PARTS READY FOR ASSEMBLY

Figure 2. The parts are procured mostly from an old phonograph horn loudspeaker unit. The preparation and assembly of these parts calls for no special skill or equipment

What Tube Shall I Use?

This article introduces a new series presenting complete data for use in selecting the best tubes for any particular service. This and the second article next month will be confined to tubes for the audio output stage

By Joseph Calcaterra

Part One

JUST a few years ago a single type of vacuum tube, usually referred to as a "general purpose" tube, performed all the functions of detector, radio and audio-frequency amplifier, output amplifier and oscillator. The marvel of hearing a program broadcast many miles away was so great that the deficiencies from the standpoint of quality and volume were overlooked.

As the novelty wore off, however, the demand for better quality and greater volume became insistent, and to meet that demand, research laboratories focused their attention on the development of tubes, circuits and equipment having electrical characteristics that made them especially suited for the individual requirements of the various sections of a radio circuit. As a result, the "Jack-of-all-trades-but-master-of-none" tube has been superseded by a number of "specialist" tubes which make possible the efficient receivers of today.

It's a far cry from the 15 milliwatts maximum undistorted power obtainable from the –01A tube to the 11,500 milliwatts now obtainable by using two –50 tubes in push-pull. Due to the improved transformers and circuits now available, even higher undistorted outputs are available by parallel push-pull combinations.

Keeping Informed on Tubes

With the rapid progress in improved tubes and their widely varying characteristics, however, it is important for the receiver designer, experimenter, serviceman and dealer to keep pace with the parade.

Most of the information available on vacuum tubes is arranged under the heading of single-tube types. Complete information regarding the characteristics and uses of each type of tube is contained in a single bulletin or article. While this arrangement is ideal when information regarding a particular type of tube is required, it is not the most logical arrangement when it is desired to find the tube best suited for a given use, since much time must be wasted in studying the individual characteristics of a large number of different types of tubes to determine the one best suited for a desired purpose.

In the series of articles, of which this is the first, the author has attempted to classify tubes according to their suitability for use in various sections of a radio circuit, giving complete information on the comparative characteristics which make them particularly suited for such applications.

With this arrangement of tube data, the selection of the best tube for any given application, and the operating characteristics which should be used for best results, can be determined much more easily than is possible when the tubes are taken one by one.

No attempt has been made to go into the theory of vacuum-tube construction and operation, since that information has already been covered in articles which have appeared in previous issues of RADIO NEWS and in a number of books now available.

The radio-tube industry has attained a high degree of standardization within the last few years. The confusion resulting from dissimilar tube characteristics for tubes designed to perform a given function has been eliminated by coöperation among tube manufacturers who have realized the advantages of conforming to certain predetermined specifications of the standardization committees of the industry.

While the quality of tubes from the standpoint of life and operation may vary to some extent with different makes, the general characteristics of tubes of any given type are approximately the same, although the designations used by different manufacturers may vary.

In Table I, the general designations used by RADIO NEWS are given with the equivalent tube type designations of the leading tube manufacturers. The values given in Table II and in the tables of any given manufacturer are average values. Individual tubes may be expected to vary somewhat from the nominal values, but such variations are of small importance except when the tubes are to be connected in parallel or in push-pull, in which case the tube characteristics should be measured and only matched tubes used for that purpose.

Four Classes of Tubes

The author wishes to acknowledge with thanks the coöperation given him by the various manufacturers, whose tube designations are given in this article, in supplying him with the latest technical data on their tubes. Special thanks are due to E. T. Cunningham, Inc., for their kindness in taking the time and trouble to coöperate with the writer.

Tubes may be divided into four groups or logical classifications according to the power supplies which serve as the source of filament, plate and grid voltages.

For the purposes of this series of articles we shall consider Group 1 to consist of tubes which are especially suited for use with 110-volt a.c. power lines and generally referred to as a.c. tubes.

In Group 2 we shall consider those tubes which can be used with a 6-volt storage battery as the source of filament voltage and current, with batteries or eliminators serving as the source of power supply. These are the d.c. tubes.

In Group 3 we shall consider tubes whose filaments are designed for use with a 6-volt source supplied either by a 6-volt storage battery or by reducing the 110-volt d.c. supply to 6 volts. These tubes

Table I **Tube Manufacturers Type Numbers**

	Type Numbers of Similar Tubes										
Radio News Type Numbers	-03	–10	–12A	–20	–31	–33	–38	–45	–47	–50	–71A
Arcturus			012-A					145	PZ	150	071-A
Ce Co.		210	112A	120	231	233	238	245	247	250	171A
Cunningham		CX-310	CX-112A	CX-220	CX-331	C-333	C-338	CX-345	C-347	CX-350	CX-371A
De Forest		410	412A	420	431	433		445	447	450	471B
Gold Seal		GSX-210	GSX-112A	GSX-120	GSX-231	GSY-233	GSY-238	GSX-245	GSY-247	GSX-250	GSX-171A
Kellogg	403										
Ken-Rad		UX-210	UX-112A	UX-120	UX-231	UY-233	UY-238	UX-245	UY-247	UX-250	UX-171A
Nat. Union		NX-210	NX-112A	NX-120	NX-231	NY-233	NY-68	NX-245	NY-247	NX-250	NX-171A
Pilot			P-112A				P-238	P-245	P-247		P-171A
Raytheon		ER-210	ER-112A	ER-120	ER-231	ER-233	ER-238	ER-245	ER-247	ER-250	ER-171A
RCA Rad'trn		UX-210	UX-112A	UX-120	RCA-231	RCA-233	RCA-238	UX-245	RCA-247	UX-250	UX-171A
Speed		210-A	112-A	120	231	233	238	245	247	250	171A
Sylvania		SX-210	SX-112A	SX-120	SX-231	SY-233	SY-238	SX-245	SY-247	SX-250	SX-171A
Triad		T-210	T-112A		T-231	T-233	T-238	T-245	T-247	T-250	T-171A

At the top are shown the type numbers adopted for use in Radio News, and below are shown the corresponding type numbers employed by a number of the leading tube manufacturers.

are especially designed for use in automobile and boat sets or for receivers in d.c. districts and many depend upon either batteries or eliminators for their grid and plate supplies.

In the last group, Group 4, we shall consider the so-called dry-cell tubes designed to operate satisfactorily with filament sources of from 2 to 3.3 volts, such as can be obtained by using 2-volt storage cells, 2-volt Aircells or a number of 1½-volt dry cells. The B and C supplies for this class are usually in the form of dry-cell B and C batteries.

While the -12A tube has been listed among the a.c. tubes, because its filament can be operated from alternating current, newer types are to be preferred for such service. Its only advantage lies in its low plate-current requirements and where a.c. supply is available this advantage is of little importance.

The -71A and -12A tubes have also been included in the second or d.c. group of power tubes, for use with storage battery filament supply and dry B and C batteries merely for comparison purposes. Even for this service, however, these tubes have been superseded in new equipment by the -38 and the -33 tubes. The -38 tube operates in a filament supply of 6.3 volts and .3 amperes, 135 volts plate, and 13.5 volts grid bias, giving an undistorted output of 525 milliwatts. The -33 tube, which can be used with either a 2-volt storage battery or an Aircell battery, draws .26 ampere and operates at 135 volts plate and 13.5 volts grid bias, giving 700 milliwatts undistorted output.

For automobile, boat and d.c. lighting districts, the -38 is in a class all by itself, its rugged filament, which is unaffected by mechanical vibration and the ordinary fluctuations in filament voltage met with in that class of work, making it specially suited for such applications.

In the dry-battery portable class, the -20 tube can still be used where low plate voltage and low plate-current characteristics are very important and power output is not so important. For other applications the -31 supersedes the -20 tube for new equipment, as an analysis of its characteristics will show. Where higher plate currents can be tolerated, the -33 tube furnishes by far the best tube for portable use. It is capable of high power output with comparatively very low plate voltage and plate-current requirements.

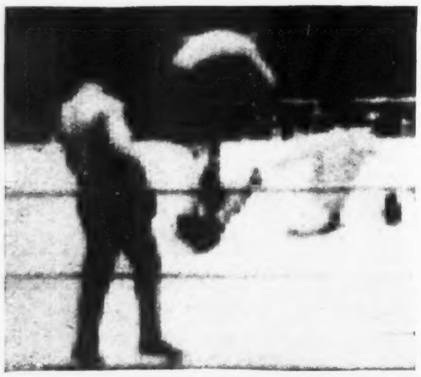
The -31 and -33 tubes were designed to present advantages over previous types when used as power amplifiers for portable sets or in receivers operated from 2-volt storage batteries or Aircells. These two tubes are ruggedly constructed and are provided with coated-type filaments to give normal life, non-microphonic characteristics and highest possible output consistent with low-voltage and low-current supply requirements. These tubes are not interchangeable with the -20 type tubes.

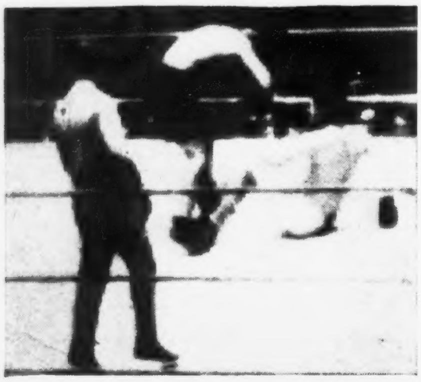
The 2-volt filament is also much better adapted for use with standard battery sources such as the Aircell.

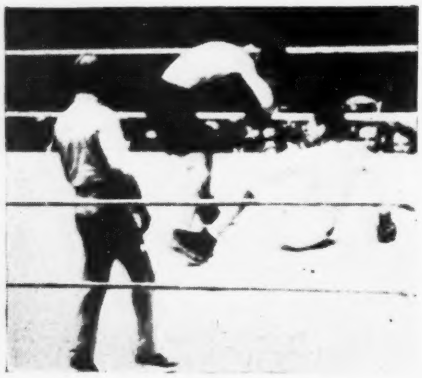
Opinions vary widely on the subject of the undistorted volume which should be delivered (*Continued on page* 886)

Table II Individual Tube Characteristics

Radio News General Type Designation	Filament or Heater Rating: Volts	Filament or Heater Rating: Amps.	Number of Electrodes	Cathode Type	Negative Grid Bias Volts Between: G & -F	G & Fil. C.T.	G & Cath'd	Plate Voltage	Plate Current Ma.	Screen Grid Volt.	Screen Grid Current Ma.	A.C. Plate Resist. Ohms	Recommended Load Resist. Ohms	Undistorted Power Output Milliwatts	Mutual Conductance Micromhos	Amplification Factor (Mu)	Base Type	Tube Dimensions: L	Tube Dimensions: D	Average List Price
GROUP 1: A. C. Tubes; "A," "B," and "C" Supply from A. C. Lighting Lines																				
-50	7 5	1 25	3	Fil.	80.0	84.0		450	55.0			1,800	4,350	4,600	2,100	3.8	UX	6¼"	2 7/16"	$6.00
					66.0	70.0		400	55.0			1,800	3,670	3,400	2,100					
					59 0	63 0		350	45.0			1,900	4,100	2,400	2,000					
					41.0	45.0		250	28.0			2,100	4,300	1,000	1,800					
-47	2.5	1.75	5	Fil.	15 0	16.5		250	32.0	250	7.5	35,000	7,000	2,500	2,500	90.0	UY	5⅝"	2 1/16"	$1.55
-45	2 5	1 5	3	Fil.	54 5	56.0		275	36.0			1,670	4,600	2,000	2,100	3.5	UX	5⅝"	2 1/16"	$1.10
					48 5	50.0		250	34.0			1,750	3,900	1,600	2,000					
					33.0	34.5		180	27.0			1,900	3,500	780	1,850					
-10	7 5	1 25	3	Fil.	35.0	39.0		425	18.0			5,000	10,200	1,600	1,600	8 0	UX	5⅝"	2 1/16"	$7.00
					27.0	31.0		350	16.0			5,150	11,000	900	1,550					
					18 0	22.0		250	10.0			6,000	13,000	400	1,330					
-71A	5.0	.25	3	Fil.	40.5	43.0		180	20.0			1,850	5,350	700	1,620	3.0	UX	4 11/16"	1 11/16"	$ .90
					27.0	29.5		135	17.5			1,960	3,500	370	1,520					
					16.5	19.0		90	12.0			2,250	3,200	125	1,330					
-03	3.0	1 5	3	Heater			40.0	180	20.0			2,500	5,000	660	1,200	3.0	Spec.			
-12A	5.0	25	3	Fil.	13.5	16.0		180	7.6			5,000	10,800	260	1,700	8.5	UX	4 11/16"	1 11/16"	$1.50
					9 0	11.5		135	6.2			5,300	8,700	115	1,600					
GROUP 2: D. C. Storage Battery Tubes; "B" and "C" Supply from Dry Batteries or "B" and "C" Eliminators																				
-71A	5 0	25	3	Fil.	40.5	43.0		180	20.0			1,850	5,350	700	1,620	3 0	UX	4 11/16"	1 11/16"	$ .90
					27.0	29.5		135	17.5			1,960	3,500	370	1,520					
					16.5	19.0		90	12.0			2,250	3,200	125	1,330					
-38	6.3	.3	5	Heater			13.5	135	9.0	135	2.5	102,000	13,500	525	975	100.0	UY	4 5/16"	1 9/16"	$2.75
-12A	5.0	.25	.3	Fil.	13.5	16.0		180	7.6			5,000	10,800	260	1,700	8.5	UX	4 11/16"	1 11/16"	$1.50
					9.0	11.5		135	6.2			5,300	8,700	115	1,600					
GROUP 3: D. C. Tube for Automobile or D. C. District Use; "B" and "C" Supply from Dry Batteries or Power Supply																				
-38	6.3	.3	5	Heater			13.5	135	9.0	135	2.5	102,000	13,500	525	975	100 0	UY	4 5/16"	1 9/16"	$2.75
GROUP 4: Low Voltage (Dry Cell) D. C. Tubes; "B" and "C" Supply from Dry Batteries.																				
-33	2.0	.26	5	Fil.	13.5			135	14 0	135	3 5	50,000	7,000	700	1,500	75 0	UY	4 11/16"	1 11/16"	$2.75
-31	2.0	13	3	Fil.	22.5			135	6 8			4,950	9,000	150	760	3 8	UX	4¼"	1 9/16"	$1.60
-20	3.3	132	3	Fil.	22.5			135	6 5			6,300	6,500	110	525	3 3	UX	4⅛"	1 3/16"	$3.00
					16.5			90	3 0			8,000	9,600	45	415					







The MARCH

In Televising Scenes—

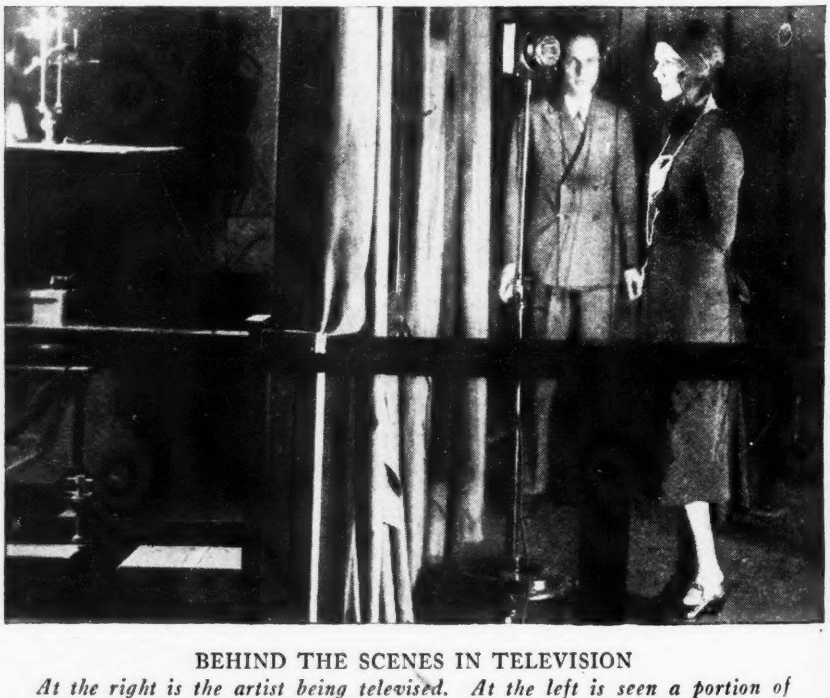
¶ *Which would you choose of the five television views at the left as having sufficiently clear definition for satisfactory home television? The Editors would appreciate hearing from readers as to their decisions. If you are interested, simply drop a note to the Editors,* RADIO NEWS, *giving the number of the picture you would choose, starting with number one at the top*

***By* Lieut. William**

Part

IN recent years television research has been directed mainly toward the improvement of definition. This general term covers the clearness of the image, its size, and to some extent its color. On definition, or its vaguer corollary entertainment value, hinge all arguments as to what television is or is not today and all speculations about its future possibilities. Definition is quantitatively stated as the number of elements, or minute areas of varying light and shadow, into which the picture is separated by the scanning process. If the scanning proceeds along successive parallel lines, as it does in present systems, the number of these lines is roughly the square root of the number of elements. A single square inch of photographic magazine illustration may contain ten thousand separate elements, and would be spoken of as a "hundred-line picture." It is obvious that increasing the number of lines increases, also, the number of elements and therefore improves definition. In general, the number of lines used in transmitting and receiving scanners is the best single index of television progress, for this line number is in fact the yardstick of definition.

Technically praiseworthy though present 60-line television may be, it does not seem to attract any large proportion of the buying public. The great question in television development is: What definition must be attained before the average home owner will buy a televisor to install beside his radio? What will be "acceptable" definition? The answer depends largely on what the average home owner expects to see. If two or three people in semi-closeups were to remain the limit of television's field of view, the present 60-line picture might possibly suffice. But the public undoubtedly wants to see football games and public events of all sorts, the national air races, the chorus of a musical comedy—anything and everything that it hears now. Furthermore, it has been led to expect, by the predictions of prominent executives, that it will see them shortly. To get some idea of how a football game would look in a 60-line picture, one has only to visualize it in a square inch of ordinary newspaper photograph viewed through a magnifying glass. It is evident that a much clearer picture than this is required. Perhaps the



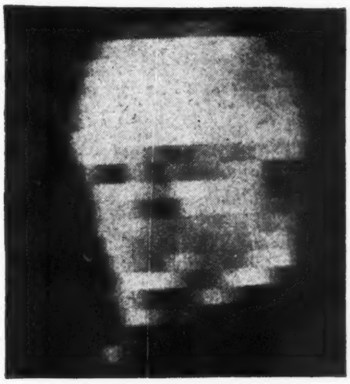
BEHIND THE SCENES IN TELEVISION

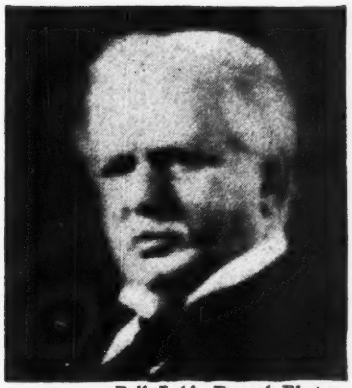
At the right is the artist being televised. At the left is seen a portion of the room in which the television transmitter is located

of TELEVISION

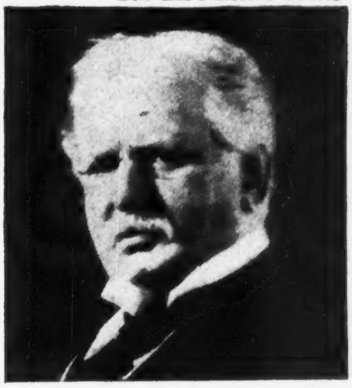
—In Televising Faces

¶ *Which would be acceptable, number one at top to number five at bottom? Number one pictures in both cases contain over 600 picture units, number two contain over 1,000 picture units, number three contain over 3,000 picture units, number four contain 12,000 and number five contain more than twice this latter number. You will note that, for faces, less detail is required than for televising scenes*





Bell Lab's Record Photos



H. Wenstrom, U.S.A.

Two

logical assumption would be that television must approximate the definition of home movies before it can take a permanent place in the home.

While home movie definition is vaguely familiar to most of us, for comparative discussion it must be evaluated in lines per picture. In the Bell Laboratories Record for April, 1931, is an article by D. K. Gaunett which includes several pictures of varying clearness, labeled with the number of elements to which each corresponds. A home movie projector was set up and operated until the moving figures on the screen approximated in size the figures in Mr. Gaunett's pictures. The projector was then stopped, both to immobilize the figures and to discount the integrating effect of motion on image clearness; and the figures on the home movie screen were compared with the still pictures. When the still picture corresponding in clearness to the home movie image was found, the number of elements was read directly beneath the former and multiplied by the ratio between the movie screen and still picture areas. Needless to say, the comparison was made several times with different types of movie scenes in order to check the accuracy, and the results are only approximate at best. But they are accurate enough to show that home-movie definition is far beyond present television definition. The rather startling result was that the home-movie picture could be considered as having about 190,000 elements; in other words, it was a 440-line picture. Considering the probable errors of the method, it is enough to say that home television should produce a 400-line picture before it will be on a par with home-movie pictures.

If this 400-line picture is the goal of television research, when will it be attained? Of course, this question cannot be definitely answered at the present time, but some inkling, more likely to be true than false, is offered by the increase of definition that has been attained during the last few years. In the 1927 demonstration the Bell Laboratories showed a 50-line picture. In 1931 home-television transmitters and receivers are being standardized on a 60-line picture. This 20 percent increase in definition, measured against four years of determined research, does not loom very large. Yet no one who has seen them in action can doubt the ability of the men engaged in television research, nor can he fail to admire their work. What, then, is the answer to this paradox of able workers and negligible (*Continued on page* 876)

CATHODE RAY TELEVISION RECEPTION

This is how faces appear when received over the Von Ardenne cathode ray system, which employs no scanning discs in its operation

RADIO "BLOODHOUNDS" PICK UP THE SCENT
The "flying squad" leaving the post office to find the 400,000 radio "pirates" estimated within the London area. Whether the radio sleuths actually used direction-finders or relied on their ears in locating set-users is a question now puzzling Britishers

British Radio Hoax
Traps "Pirate" Listeners

By Austen Fox

THE British Post Office has just "put across a hoax" on its trusting public which would make Tammany blush for shame—or, what is more likely, turn green with envy.

It all has to do with the affair of the detective "radio cars" created for the purpose of tracking to their lairs "pirate" radio listeners throughout the British Isles. As everyone probably knows, the British radio receiving-set owner must obtain a listener's license at the rate of ten shillings ($2.50 at par exchange) per year. Otherwise he is apt to have government inspectors descend upon him and padlock his radio set—or collect ten shillings. There is, of course, no danger of getting into jail for bootlegging radio programs over there—not any more than in America for running an "alleged" speakeasy.

Radio Tax Pays for Programs

But the British public as a whole is essentially honest. They go down and buy their licenses at the local post-office because they feel that a government decree or order is made to be obeyed. It has apparently struck them that it is entirely fair to expect them to pay a small license fee, a part of which, at least, goes to the monopoly company maintaining their broadcasting programs. They prefer this to advertising; they feel that they get better programs by such independence from commercialism. In this they are evidently more or less right. At least they do not have to get up every ten minutes to tune out some long speech about the advantages of Pale Pills for Pink Toothbrush, as most of American radio listeners do.

After some time, the General Post Office, however, began to grow suspicious of its honest public. The statistics on sales of receiving sets, parts, etc., did not seem to jibe with the number of listeners' licenses taken out. There were too few of the latter; anyway, some cynics started whispering nasty innuendos about human nature, and all that.

With true British caution, they did nothing for a while. They carefully looked over the ground, and discussed the problem from every angle. The general and the radio press likewise discussed it. Nothing came of the fuss, and the Post Office, like Br'er Rabbit, lay low and said nuffin'. The pirating of programs went right on as before. After all, what could they do about it? To maintain a great corps of inspectors would cost more than it was worth. To send a few here and there to catch and punish offenders might be partially effective, but it left the field pretty well uncovered. To spot the pirates otherwise seemed to be just an engineering impossibility.

Radio Bootleggers—Warning!

Suddenly, during the Fall of 1931, the radio public of England was awakened with a violent shock. The Post Office authority published an announcement, which was taken up and given plenty of space in the daily and the wireless press, that they were "out to get" these license dodgers, and no fooling about it either. They did not mince words—they said that it was just so much dishonesty, and that they would deal summarily with anyone caught. They were tired of letting fifty to one hundred thousand people sit around enjoying these programs on which the British Broadcasting Company had labored so long and lovingly, all at the expense of the honest people of the island.

Being truly British, they were sporting about the warning. They told the people just when they were starting off on their crusade of reform, and they also told just how they were going to achieve their results. A broadcast (*Continued on page* 874)

The "Complete" Service Unit

This month the author and designer concludes his description of the construction and operation of one of the most useful instruments yet devised for service work

By W. Gerber
Part Two

TO put the tube checker in operation, plug the power line cord into the outlet O^R and the nearest electric outlet. Place the tube to be tested in either the UX or UY sockets and set switch S3 to the filament voltage of the tube. If the tube is of the pentode, screen-grid or vario-mu type, the adapters appearing in Figure 4 (a) or 4 (b) will have to be used. Selector switch S1 is placed in the "T.M." position, while all other switches should be in their normal position. The first reading (normal plate current) is obtained by locking down the "ma." button S14. Button S9 is pressed to obtain the second reading, which is the grid-bias change. Switch S6 is changed from the "Normal" position to the "Neutral" position to place the tube in oscillation for the last reading. The circuit diagram, Figure 1, shows how the switch S6, when in the "Normal" position, shorts the oscillator L1 and when in the "Neutral" position allows the condenser C6 to tune the coil. The adapter appearing in Figure 4 (c) is to be used when testing the second plate of a 280 rectifier tube. If any readings are below 10 ma., the "10 Ma." button S11 is pressed. When readings are above 10 ma., the button is not pressed; in this case readings are taken on the 50 ma. range of the meter.

A conventional Hartley type oscillator was included as part of the tube checker inasmuch as it can be a.c.-operated and afford an oscillation test on tubes. The oscillator coil and its associated wires are shielded to prevent pick-up of r.f. energy which has not passed through the dummy antenna. Two r.f. chokes, RFC1 and RFC2, are placed in the power line to prevent the r.f. energy from the oscillator from leaking back into the power line and interfering with the adjustments on the set. The feedback effect takes place through the blocking condenser C7, which has a capacity of .005 mfd. Condensers C1 and C2 isolate the dummy antenna's grounded connection to the set. Fuses F1 and F2 protect the filament transformer T1 and its associated apparatus in case of a short circuit.

The oscillator coil L1 is wound with 106 turns of No. 24 enameled wire on a form 1¼ inch in diameter and 3 inches long, center tapped. The dummy antenna coil L2 is wound over the coil L1 and consists of 25 turns of No. 30 enameled wire.

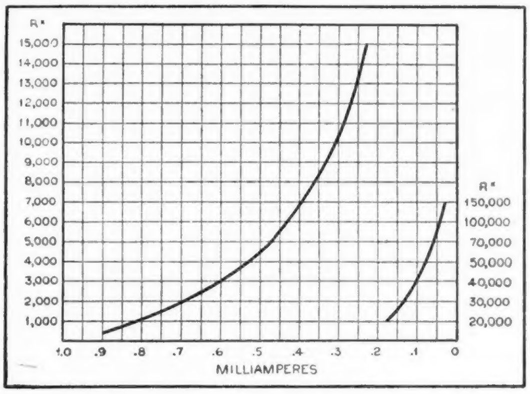
Chokes RFC1 and RFC2 each consist of 300 turns of No. 30 enameled wire jumble wound on a form 1¼ inches in diameter and 1½ inches long.

Switch S6 selects the three fundamental frequencies. Since each fundamental frequency has a certain number of harmonics, the frequency range of the oscillator is thus greatly increased, thereby extending its utility.

It is next to the impossible to try to calculate the capacity of condensers C4, C5 and C6 in order to tune the coil L1 so that it will generate a predetermined frequency. The author suggests that for the low frequency the condenser C4 should have a capacity around .005 mfd., for the high frequencies between 500 and 1000 kilocycles C5 and C6 should have capacities of .001 and .0005 respectively.

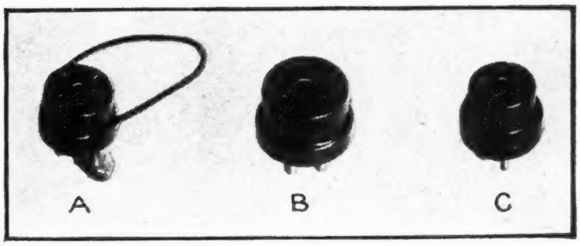
The oscillator is put in operation the same way as the tube checker. It is recommended that a –71A or –45 power tube be used. The output of the oscillator is connected to the antenna and ground posts of the set by means of a special shielded cable having phone tips on one end and clips on the other. This cable can be made of a five-foot length of insulated wire over which copper braid shielding is pushed. The antenna connection goes to the insulated wire and the ground connection to the shield.

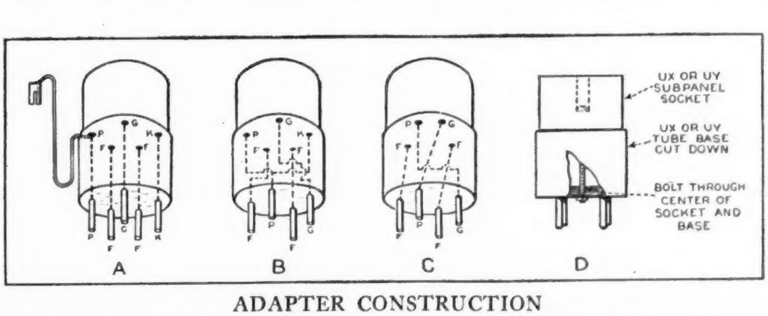
If the operator desires, the output meter may be connected to the output of the set. In this case, selector switch S1 will have to be in the "BP" position. The output range desired is selected by pressing buttons S14, S15 or S16.



RESISTANCE MEASUREMENT CHARTS

Figure 3. This calibration curve covers resistance measurements up to 150,000 ohms. For a 15,000-ohm range use the 10 ma. scale and divide the values Rx by ten





ADAPTER CONSTRUCTION

Figure 4. Details for making the various adapters required. A is the adapter for screen-grid tubes, B for pentode tubes and C for –80 type tubes to permit measurement of the second plate circuit. D shows the mechanical assembly details

D.C. Volt-Milliammeter

The use of a single instrument for the voltmeter, ohmmeter, milliammeter and output meter keeps the cost and size of the tester to a minimum. A Jewell Pattern 88, 0-1 d.c. milliammeter was chosen for the basic instrument. Through the use of multipliers and the proper switches, five voltmeter, four milliammeter, two ohmmeter and three output meter ranges are available. All scale ranges were chosen so that the meter may be considered direct reading, since it is only necessary to multiply the scale values by 10, 50, 100, 250, etc. A Jewell Pattern 88, 0-10-100 double-range scale has enough space for three or four additional scale ranges which the constructor can put on with the aid of a quill pen, a bottle of black India ink and a steady hand.

Milliammeter ranges of 10, 50 and 100 are obtained by the use of No. 26 German silver or nichrome wire wound on spaghetti tubing so that the finished units are flexible. A convenient mounting block can be made of 3/16-inch bakelite panel, 6 inches long and 1¼ inches wide, drilled to accommodate the screws and lugs to which the shunts are connected. This mounting block is supported over the sockets on the under side of the main panel by means of 1¼-inch screws and ⅞-inch sleeves.

All wiring to and from the shunts and switches must be finished before the shunts are calibrated. Hook up a 4.5-volt C battery and a 5000-ohm variable resistor in series with two leads having clips on one end. Assuming that all connecting wires are soldered in place, proceed to calibrate the shunts as follows:

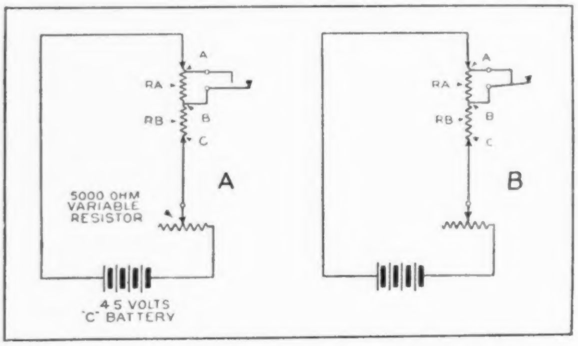


FIGURE 5. SHUNT RESISTOR CALIBRATION

Connect the 4.5-volt C battery and 5000-ohm variable resistor in series with the 0-1 milliammeter and adjust the variable resistor for full-scale deflection on the meter. Then, without touching the resistor, disconnect the C battery and resistor from the meter and connect across points A and C, Figure 5 (a). Set the selector switch S1 and button switches S11, S12, S13 and S14 so that the meter is in parallel with resistors Ra and Rb. If the meter is to be calibrated for a 10 ma. reading, the length of shunt R15 is varied until the meter indicates 1/10 of full-scale deflection. (Shunt Ra corresponds to the 10 ma. shunts R11, R13, R15, Figure 1; shunt Rb corresponds to the 100 ma. shunts R14 and R16 and 50 ma. shunt R12.)

When the 10 ma. shunt has been calibrated, we may proceed to the 50 or 100 ma. shunts corresponding to Rb, Figure 5. The variable resistor is turned until the meter indicates full-scale deflection with the 10 ma. shunt. Release button S11 so that it shorts the shunt Ra, Figure 5 (b). Proceed to adjust length of same until meter indicates 1/10 full-scale deflection for a 100 ma. shunt, or 1/5 full-scale deflection for a 50 ma. shunt. Shunt R18 is calibrated by pressing buttons S12 and S10 and adjusting its length until the meter indicates ½ full-scale deflection on its 1 ma. range. The variable resistor and 4.5-volt C battery, of course, being connected across it. Shunts R8, R9 and R10 are calibrated in the same way, that is: the meter is adjusted for 1/10 full-scale deflection on the 10 ma. range and ½ full-scale deflection on the 50 ma. range to obtain milliammeter range of 10, 50 and 100 ma. respectively. The selector switch S1 being in the "BP" position for calibration of these shunts. Refer to the parts list for the milliampere value of the shunts. All shunts should be rechecked to make sure that no mistakes have been made in calibration.

The continuity circuit comprising the 0-1 milliammeter, M1, variable resistor, R2, and 4.5-volt C battery, B1, is also utilized for resistance measurements up to 150,000 ohms. Resistance curves for these measurements appears in Figure 3. The selector switch is placed in the "BP" position and the button S14 pressed. Switch S5 is left in the neutral position for 150,000-ohm range and placed in 10 ma. position for the 15,000-ohm range. Tip jacks J12 range, and J11 are shorted and the zero adjustment resistor R2 is adjusted for full-scale deflection of the meter. The short is removed from jacks J12 and J11 and the unknown resistance put in its place.

Output measurements are made through jacks J13 and J14, the range being selected by pressing buttons S14 and S15 or S16. Sometimes better results may be obtained by reversing the connections to the crystal rectifier C4.

A calibration curve for capacity measurements can be made through the use of standard capacities, the a.c. meter and a.c. line, which are connected by means of a pair of leads equipped with an a.c. plug and phone tips.

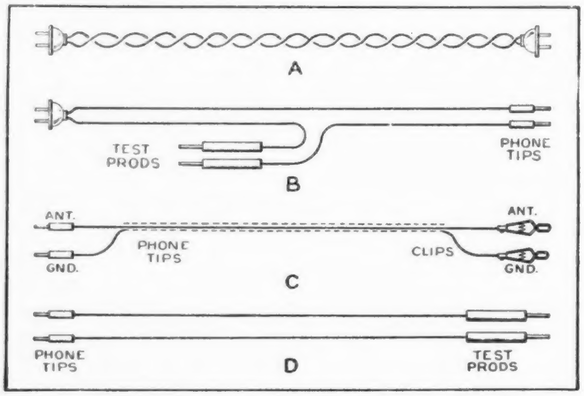
External voltage measurements are made with S5 in the neutral position. The range desired is selected by pressing buttons S15, S16, S17, S18 or S19.

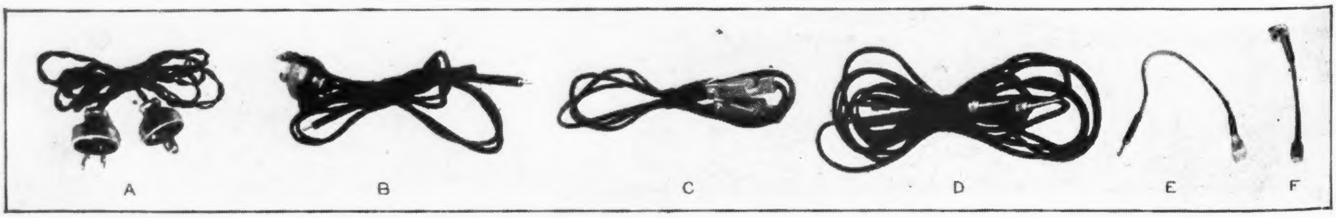
A.C. Volt-Ammeter

Due to changes in manufacture, the resistance value in the instrument catalogues is not always as marked. Therefore the constructor should ascertain the correct resistance of the meter before actual construction on the current transformer is started. The transformer's principle of operation is not quite so complex as one might imagine.

A voltage drop occurs across the primary winding whenever an alternating current flows through it. This voltage drop, which is due to the impedance of the winding, induces a voltage in the secondary winding in proportion to the amount of current flowing in the primary. If the following formula is used the meter will indicate directly on the 3-volt range any current up to 3 amperes flowing in the primary.

$F = \frac{I^1}{I^2}$ where I^1 is the maximum current to be measured (which in this case is 3 amperes). I^2 the current the meter requires for full-scale deflection, F the multiplication factor to find the number of secondary turns necessary to produce full-scale deflection (3 volts), when the maximum current (3 amperes) is flowing through the primary. Fifteen turns of No. 18 enameled wire will be found quite satisfactory for the primary winding in most cases. To find the number of secondary turns necessary, multiply the fifteen turns of the primary by the multiplication factor. A No. 30 or No. 32 enameled wire will be found suitable for the secondary. The core may be that (*Continued on page* 887)





THE MISCELLANEOUS CONNECTORS

Figure 6. The photos show actual views of the various connectors and the corresponding drawings show them in schematic form. A is the a.c. line cord; B, the leads used in making capacity measurements; C, the oscillator output lead (using shielded wire, with the shield as one conductor); D, the test leads; E, the control-grid lead for screen-grid tubes; and F, the plug-button connector (see text)

CHARACTERISTICS AND CIRCUIT DESIGN DATA FOR TWO

NEW TUBES

TYPE 239

A radio-frequency pentode, the 239, intended for d.c.-operated receivers, has been announced. Amateurs and experimenters will be especially interested in a new voltage amplifier tube, the 841. This article contains data on these two tubes and additional information on the triple-twin tube

By J. van Lienden

TYPE 841

TWO new American tubes have recently made their appearance. The first, which will be known as the 239, is called the super-control radio-frequency pentode. This is an addition to the 6-volt automobile types of tubes. The second is a voltage-amplifier tube, type 841, with a filament like that of the 210 but with an amplification factor of 30.

The Radio-Frequency Pentode

Until recently, pentodes have been used in this country mostly in output stages, but the addition of a suppressor grid now makes the screen-grid tube more efficient for radio-frequency amplification.

When the ordinary screen-grid tube is used with a relatively low plate voltage, it may happen that during the reception of a strong signal the plate voltage swings below the screen voltage. During this part of the cycle the plate circuit has a negative resistance. Its dynatron action causes distortion and therefore the signal must be kept within these limits.

The secondary emission from the anodes, by the bombarding of the primary electrons attracted from the cathode, is always present. It becomes more pronounced when the screen voltage becomes higher and the plate voltage lower. At a certain plate voltage this produces an effect where the plate resistance and the transconductance suddenly drop and operation is impractical beyond this point.

In the 239, a suppressor grid, or cathode grid, has been placed between the plate and screen, or space-charge grid. This grid is connected to the cathode inside the tube. The presence of this additional grid prevents the passage of secondary electrons from plate to screen, or vice versa. The plate resistance and the transconductance now remain nearly the same at lower plate voltages, whereas at high plate voltages the gain is increased.

The radio-frequency pentode can now be used when the plate voltage cannot be high, as for instance in d.c.-operated receivers. The plate-voltage, plate-current characteristics show that the slope remains nearly the same, down to about 60 volts, with a screen voltage of 90 volts. With the screen-grid tube this would be impossible, for then it becomes a dynatron oscillator. At the end of this article, Table 1 gives the characteristics of the 239 as furnished to us by the Radio Corporation of America and the Eveready Raytheon ER-239 by the National Carbon Company.

In Figure 1 is shown a schematic circuit of a simple stage of radio-frequency amplification employing the radio-frequency pentode. If the highest possible gain is to be realized, the load impedance must be very high; a tune circuit should be the most effective.

If necessary, the screen-grid may be connected to the same point on the voltage divider as the plate, with a resistance inserted. But if the plate voltage is only 90 volts, it can be connected directly to the same point as the plate.

The dynamic characteristic of the 239 is such that it can be used as a variable-mu tube. The amplification—that is, the transconductance—can be varied by a change in grid

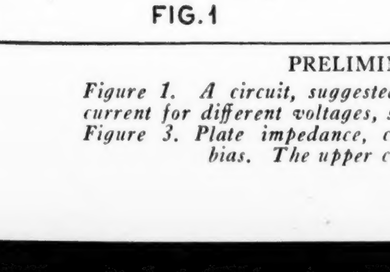
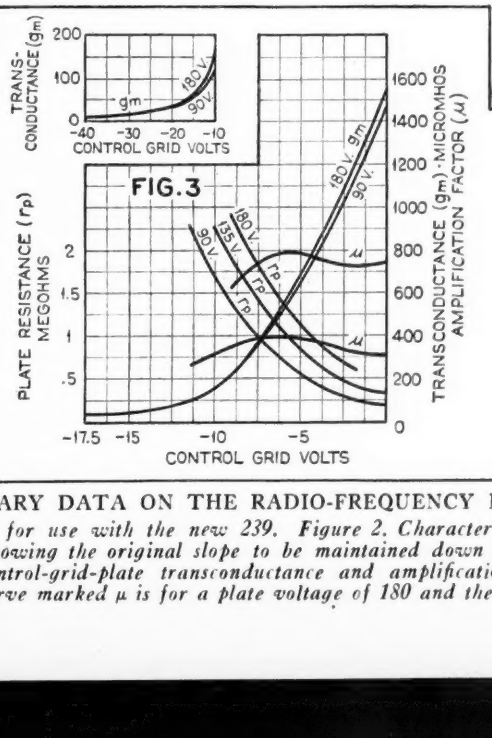


FIG.1



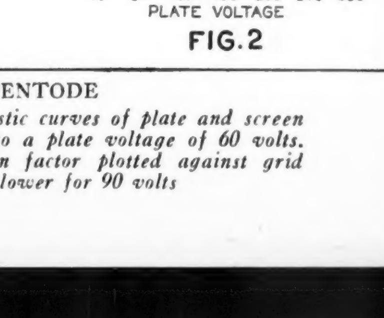


FIG.2

PRELIMINARY DATA ON THE RADIO-FREQUENCY PENTODE

Figure 1. A circuit, suggested for use with the new 239. Figure 2. Characteristic curves of plate and screen current for different voltages, showing the original slope to be maintained down to a plate voltage of 60 volts. Figure 3. Plate impedance, control-grid-plate transconductance and amplification factor plotted against grid bias. The upper curve marked μ is for a plate voltage of 180 and the lower for 90 volts

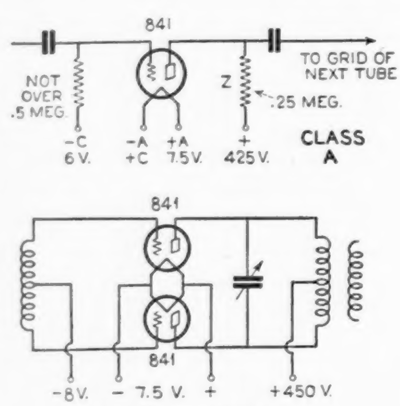


FIG. 4 CLASS B

CIRCUITS FOR THE 841

Figure 4. The voltage amplifier tube used as a Class A or Class B amplifier as explained in the text

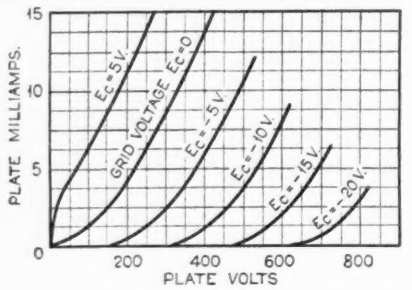


FIG. 5

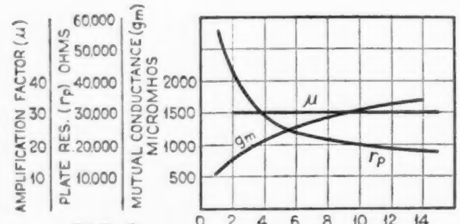
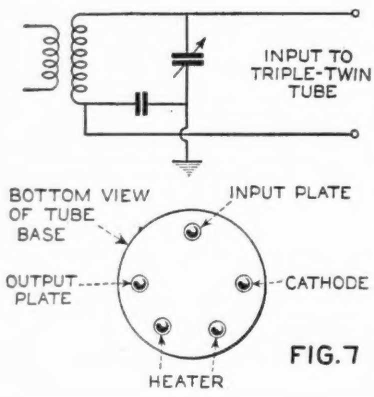


FIG. 6



INPUT TO THE TRIPLE-TWIN

Figure 7. If the triple-twin tube is used as a detector-amplifier, the input must be changed to the circuit shown

CURVES ON THE 841

Figure 5. Curves showing the relation between plate voltage and plate current, for different grid voltages. Figure 6. Plate impedance, amplification factor and mutual conductance plotted against plate current

bias. There are three distinct ways in which this can be attained.

The first one is by varying the grid bias, with a potentiometer across the C battery or across a part of the voltage divider (see Figure 1). In that case, when varying the grid bias, nothing else is changed and the dynamic characteristic remains the same. This gives a nice gradual control of the volume.

The second method is by inserting a rheostat in the cathode lead. This resistance, when varied, does not alone vary the grid bias, but also the screen voltage and the plate voltage. Therefore, the dynamic characteristic is continually changing. Increasing the grid voltage *decreases* the screen potential and the falling off in volume is then more rapid when using this method of volume control.

In the third method, the volume control is in the cathode lead. The screen lead now includes a resistor with a condenser across it. The drop in the resistor varies with the decreased screen-grid current and the screen voltage can be made to *rise* with the decrease of the grid bias. It is claimed that this method is an improvement for the handling of larger signals and is an aid toward automatic volume control.

As well as in a radio-frequency and an intermediate-frequency amplifier, the 239 can be used as a resistance-coupled amplifier and also as a first detector in a superheterodyne. It cannot be made to work as a regular detector.

Summing up the advantages of the 239 above other radio-frequency amplifiers, we find that it is especially useful in automobile receivers and in sets designed for 110-volt (d.c.) operation. All the automobile type tubes draw a filament current of 300 ma., therefore they all can be connected in series across the line, with a properly chosen series resistance. The gain possible with the pentode is far greater than with any of the screen-grid tubes now in use. The variable-mu feature reduces cross modulation and permits a more convenient way of controlling voltage. The constancy of the screen current allows a simplification of the voltage-divider design.

The 841 should be of interest especially to amateurs and experimenters. It is a three-electrode tube similar in appearanc to the 210 and takes the same filament and plate voltages. It has a high amplification factor and is chiefly intended as an amplifier tube in resistance-coupled and impedance-coupled circuits. It can be used also as an oscillator, a crystal-controlled oscillator, a radio-frequency power amplifier, a frequency doubler and as an output tube in push-pull or Class B amplifiers.

The characteristics of the tube were given by the manufacturer in four groups according to the type of service. It would be best for us to follow this in the same order.

When the 841 is employed as an amplifier in resistance or impedance-coupled amplifiers, where fidelity is more important than efficiency, the tube should be operated only over the straight portion of its dynamic characteristic. This is generally called Class A service.

In Figure 4A is shown the diagram for a single-stage amplifier using an 841 type tube. Z can be either a resistance or a choke. If it is a resistor it should be of 250,000 ohms. The grid return is to the negative side of the filament, if it is heated by d.c. If a.c. is used, the grid return is brought to the center-tap and then the grid bias should be increased with 3.75 volts, one-half of the filament voltage. This goes for all the different uses of the tube: The grid bias given in this article is for d.c.; when you use a.c., add 3.75 volts.

The characteristics for the tube when used as a Class A amplifier are shown in Table 2.

The plate voltage given here is that of the plate supply, the effective plate voltage is less because of the drop in the load resistance.

The same principles could be applied to the use of this tube as a radio-frequency amplifier.

The push-pull amplifier has lately come in for a large amount of attention. In battery-operated amplifiers it is a saving because of the possibility of using a smaller type of tube for the output stage and of the reduced drain on the B supply when no signal is being received.

This system, however, has its disadvantages, because the transformer in the input circuit has to be of a high-grade type, and, while the second harmonic can be canceled out, the third harmonic remains. However, this (*Continued on page 882*)

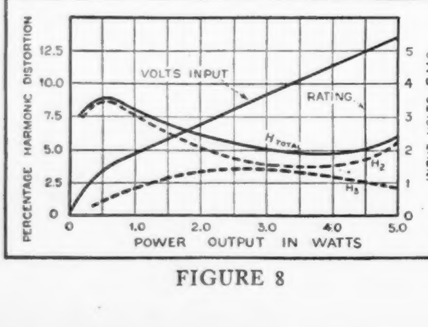


FIGURE 8

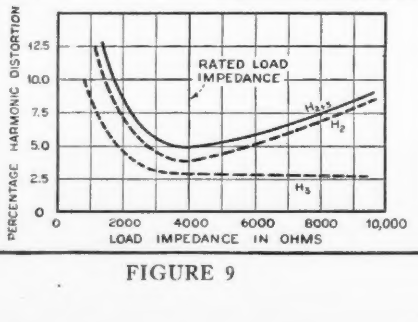


FIGURE 9

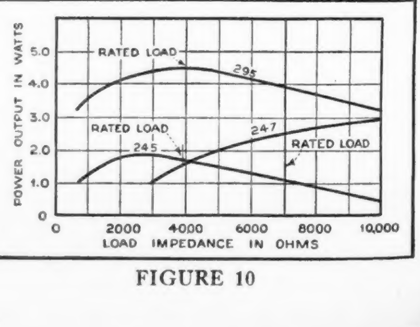


FIGURE 10

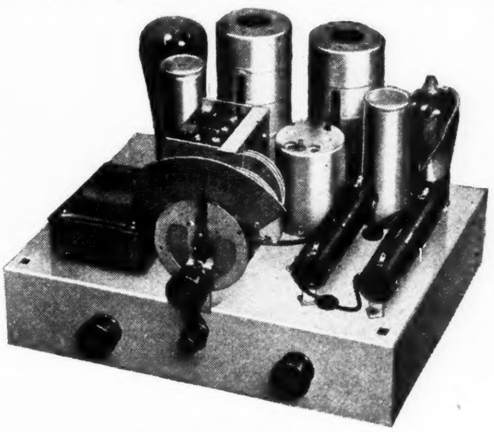
FOUR TUBES USED IN LATEST

Short-Wave Converter

This new superheterodyne short-wave converter is a.c. operated, and in addition to the usual detector and oscillator includes one i.f. stage, which may be tuned to the most effective frequency of the broadcast receiver

By **W. A. Smith***

SHORT-WAVE converters, up until a few months ago, were largely standardized in the form of two-tube units, or three tubes if they included a built-in rectifier. Many of these were highly effective, although their effectiveness often depended on the type of antenna coupling employed in the broadcast receiver with which they were used. If the coupling in the receiver input circuit were too close, the tendency would be toward broad tuning. On the other hand, if loose coupling were employed, a decided lack of sensitivity oftentimes resulted.

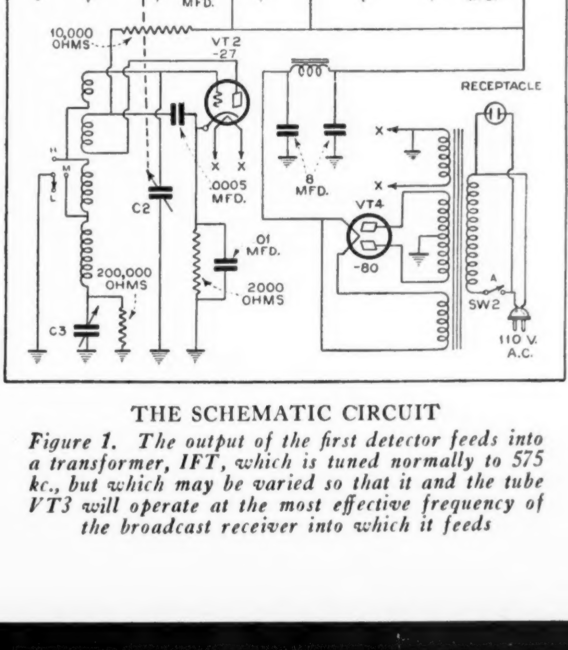


THE NEW CONVERTER
Compact in size, this unit takes up little more room than the usual type of converter, even though it provides an extra stage of amplification

The converter described here lessens this complication by including one stage of amplification after the detector and oscillator. This single stage i.f. amplifier may be tuned to the frequency at which the broadcast receiver is most selective—usually close to the low-frequency end of the dial. Or, better still, if the receiver can be tuned to a frequency just below the lowest broadcast frequency—say to 540 kc., for instance—the possibility of signals being heterodyned by broadcast stations is completely eliminated. The tuning range of the i.f. stage in the converter is wide enough to permit it to be adjusted to this relatively low frequency if desired.

New Features

This tuned i.f. stage offers two distinct advantages. First, it provides increased sensitivity, with the result that its effectiveness is influenced less by the broadcast receiver employed with it than was the case with the older types of converters. Second, the tuned circuits of the i.f. stage provide added selectivity so that the overall selectivity is not so entirely dependent on that of the broadcast receiver.



THE SCHEMATIC CIRCUIT
Figure 1. The output of the first detector feeds into a transformer, IFT, which is tuned normally to 575 kc., but which may be varied so that it and the tube VT3 will operate at the most effective frequency of the broadcast receiver into which it feeds

This converter covers a short-wave range extending continuously from 200 meters on down to 15 meters. The three ranges, *i.e.,* 200-80 meters, 80-35 meters and 35-15 meters, are selected by means of a simple switching arrangement. The plug-in coil idea has been done away with entirely.

As indicated in the schematic diagram, the coil system includes two tapped coils, one in the antenna-detector circuit and the other in the oscillator circuit. Actually, each of these consists of three spaced coils connected in series and so arranged that the unused coils are automatically shorted out. By careful design it has been made possible to gang the coil-tuning condensers to provide single-tuning control. To aid in this a series padding condenser, C3, has been included in the oscillator circuit. This flexibility in the oscillator tuning is also made necessary by the fact that the intermediate frequency is adjustable.

Operating Data

Once the converter has been connected between the broadcast receiver and the antenna, it may be left in position. The switch S1 on the converter connects the antenna direct to the receiver when reception on the regular broadcast waves is desired, by throwing to the side marked B in Figure 1. Throwing the switch to A opens the antenna circuit to the broadcast receiver, and thus cuts in the converter. The antenna is at all times connected to the converter through a low-capacity condenser (C5), but this capacity is so small that it offers a high impedance to broadcast signals and, although the converter input circuit is in parallel with the broadcast receiver input when the switch is thrown to B, there is no appreciable loss through the shunt circuit.

Shielding around the first detector and oscillator coils has not been deemed necessary. Complete shielding of the intermediate-frequency stage is essential, however, because this stage is operating at the same frequency as the broadcast receiver and, in effect, constitutes another r.f. stage. If it were not shielded the broadcast receiver would in many cases become unstable. The can which incloses the i.f. coil has two openings through which the i.f. trimmer-type tuning condensers may be adjusted and balanced. This can is shown just to the right of the gang tuning condenser in the photograph.

The built-in power supply provides all operating voltages for the adapter. Connecting it up for use is, therefore, extremely simple. Once connected, it may be left so at all times.

*Chief Engineer, Midwest Radio Corp.

MODERN RADIO PRACTICE IN USING

GRAPHS *and* CHARTS

Calculations in radio design work usually can be reduced to formulas represented as charts which permit the solution of mathematical problems without mental effort. This series of articles presents a number of useful charts and explains how others can be made

***By* John M. Borst**
Part Four

A CHART for the calculation of the total resistance of two branches or the total capacity of a series is so simple, convenient and easy to make that the author has never been able to understand why it is not used more. In contrast to the chart which was described last month there is nothing difficult about this one. Ordinary decimal scales are used and the calibrations as well as the angles are easily found.

The formulas for the solution of our problems are

$$\frac{1}{R}=\frac{1}{r_1}+\frac{1}{r_2} \text{ and } \frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$$

The similarity of these two equations makes the chart suitable for the solution of either one of them. All we say in regard to one equation or its solution is equally applicable to the other one.

In the February, 1932, issue of RADIO NEWS it was shown that this type of equation could be solved with the aid of an alignment chart consisting of three scales converging at one point. If the two angles formed at this point are equal and of 60 degrees, then the same size unit can be used throughout. It is not always convenient to make the angles of 60 degrees for a rather wide sheet of paper becomes necessary.

Fortunately, the two angles can be "anything." If the angle is α, then the modulus of the slanting scales should be

$$\frac{M_x}{2\cos\alpha}$$

where M_x is the modulus of the center scale.

When cross-section paper is used, the divisions are already present; it is only necessary to draw the three lines.

It will be seen that in the case of a large resistor, shunted by a small one, the ruler, laid across the chart for the reading of the total, will make a very sharp angle with all three scales and consequently the accuracy is not so good. This can be obviated by making another chart with unequal angles for this kind of solution. The relation still holds when the angles are unequal. This is proven at the end of this article.

The two types of charts have been united and you find them both in Figure 1. The scales marked A belong to the equal-angle chart and are intended for the solution of the average problem. The scales marked B form the scale of the unequal-angle type. When the two resistors in the problem are widely different, this is the chart to use.

If the range is not large enough for a particular problem, all values on the three scales can be multiplied or divided by any number.

Problem 1. Let it be required to find what is the resistance equivalent to 100 ohms and 150 ohms in parallel. A transparent ruler laid across the chart so that it connects 100 on one slanting scale and 150 on the other, crosses the center line at 60. This is the resistance sought.

Problem 2. Suppose there were three resistors in parallel, for instance, 150, 100 and 40 ohms. In this case, first determine the resistance of two branches in parallel, say 100 and 150; our problem No. 1. Then the equivalent resistance, 60 ohms, is in parallel with 40 ohms and the chart is used a second time. Draw a line from 60 on one slanting scale to 40 on the other and find, in the center, the intersection at 24. This is the resistance of the three branches in parallel.

Problem 3. What is the capacity of 120 and 8 micro-microfarads in series? Since here the two condensers are so widely different, it is best to use chart B. A line drawn from 120 on the right slanting scale to 8 on the extreme left scale crosses B2 at 7.6 micro-microfarads approximately. This is the capacity of the combination—smaller than the smallest.

It is of course necessary to read the same units on all scales. They should be all micro-microfarads or all microfarads for one particular problem.

Some equations, frequently used in optics, are of the same form as those here treated and therefore can be solved with the aid of the same chart.

The well-known formula, giving the relation between focal length of a lens and the distances of image and object, is

$$\frac{1}{f}=\frac{1}{i}+\frac{1}{0}$$

where f is the focal distance, i the image distance and o the object distance. Read f on the middle scales: A2 or B2.

A second one is the formula for the focal length of a system of two or more lenses.

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}$$

where F is the focal length of the system and f_1, f_2 are the focal lengths of the individual lenses making up the system. In this case F is to be read on the middle scale.

In Figure 2 are shown three scales converging at one point and with the angles p and q unequal. It is required to find the relation between the segments (*Continued on page* 888)

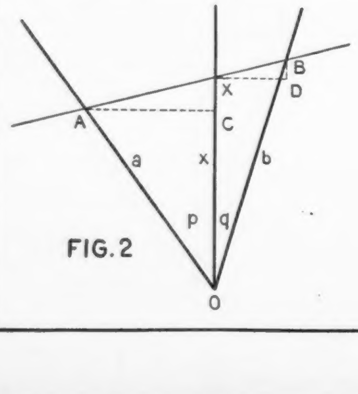


FIG. 2

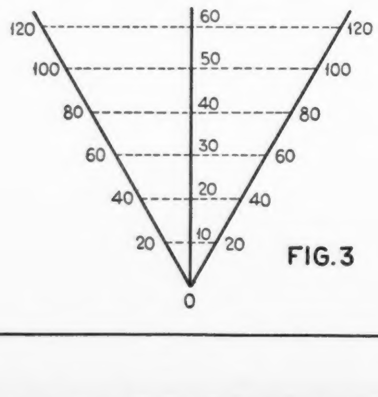


FIG. 3

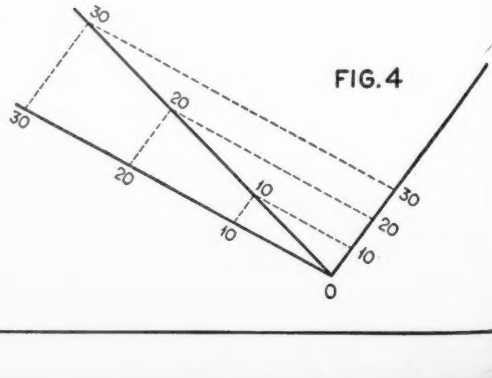


FIG. 4

Resistors in Parallel, Condensers in Series

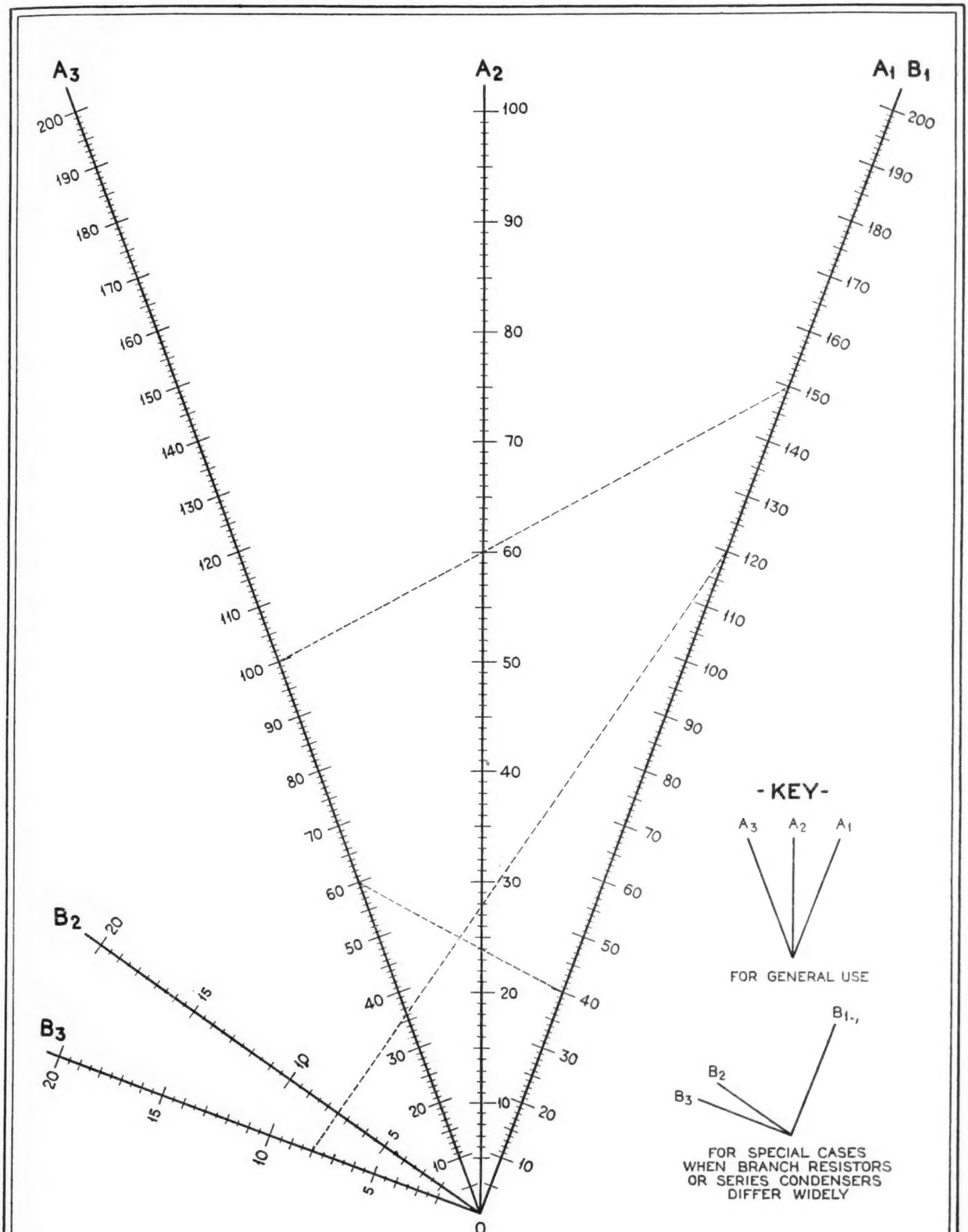
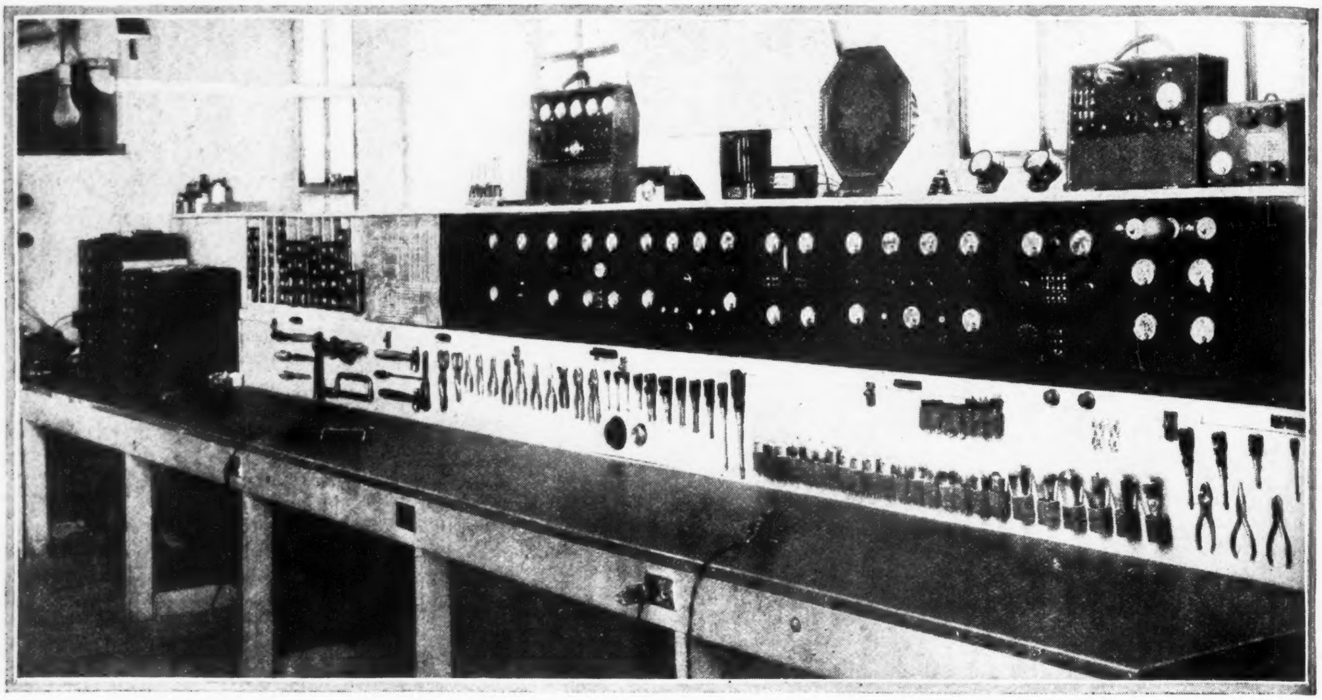


CHART SOLVES RESISTANCE AND CAPACITY PROBLEMS

Figure 1. This chart and a ruler are all that you need for the solution of total resistance of resistor branches and for the solution of total capacity for condensers in series



The Service Bench

Money leads in P. A. systems—New service sidelines—Service advertising—The Institute of Radio Servicemen—Service shops—Service kinks—Service literature

Conducted by
Zeh Bouck

THE installation of P. A. apparatus has been repeatedly recommended by the Service Bench as a lucrative service sideline. The response to these short articles has been emphatically in agreement with our premise that there is gold for the service man "in them thar hills." The following contribution by J. M. Kuhlik, general manager of the Miles Reproducer Company, New York City, a pioneer in the development and installation of public address systems, indicates further possibilities of loud-speaking equipment, and suggests profitable leads to the serviceman.

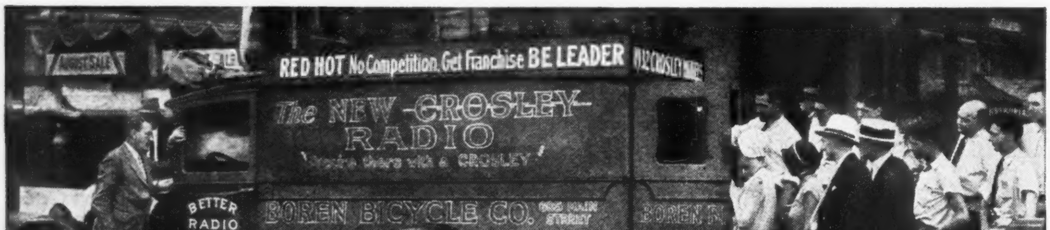
The variety of uses to which public address systems are now being put is a tribute to the ingenuity and imagination of the dealers and servicemen who sell or rent this equipment, as well as to their customers who daily discover new departures from the conventional services. Some of these new uses have their humorous side; and all of them are practical, as well as serviceable.

A prominent department store conceived the idea of letting the managers of some of the higher-priced departments listen in while the clerks were trying to sell merchandise to the customer. For example: A man walks over to the jewelry counter and asks to look at diamond rings. "How much is this one?" asks the customer. The clerk—"Fifteen hundred dollars." The customer objects, "I don't want to spend more than about eight hundred. What have you around that price?"

The manager listens into the conversation for a while, then walks up to the counter and is introduced to the customer. As he already knows what is wanted without the customer's saying another word, the prospective buyer is favorably impressed by his understanding, efficiency, etc. This system also provides the department manager with an excellent check on the sales methods of his clerks. The method worked out so satisfactorily in the jewelry department that it has now been duplicated in four other departments.

As an Aid to Hearing

Persons who are hard-of-hearing are occasionally inclined to moroseness when they feel that others are participating in an existence, partially denied them. They are often startled by seeing people before them whom they did not hear come into the room. One young man solved this problem for his mother by installing concealed microphones in the living room and lobby with loudspeaker or headphone outlets in the kitchen and in her bedroom. She now hears what is going on, and has thus been cured of various neurasthenic complications.



The Boren Bicycle Company makes highly profitable use of their truck equipped with public address apparatus. As Mr. Kuhlik points out in his article, equipment of this kind can be used, not merely for the advertising of your own business, but may be leased, on occasions, to other enterprises at a good profit. This truck puts over the name of the dealer-serviceman, as well as the product he features

Out-Hawking the Hawkers

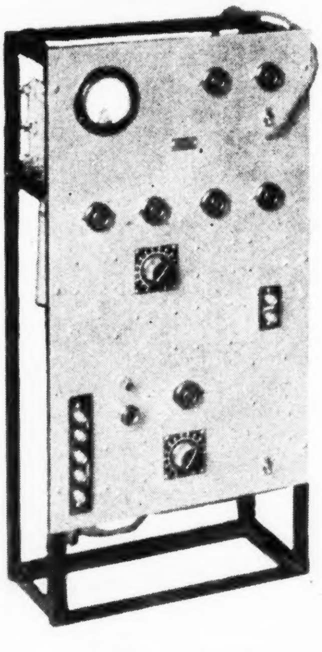
A fruit vender in a street where it is the custom of his competitors to invite buyers at the tops of their voices to purchase sundry magnificent peaches, apples, bananas, and what have you, found himself at a decided loss, due to tired vocal cords. He had installed for him an inexpensive microphone-amplifier-speaker unit, and can now be heard, any market day, out-shouting the rest by a generous margin of several watts!

The Same Idea in a Butcher Shop

A butcher on Amsterdam Avenue, in New York City, installed an electric pick-up phonograph and microphone in his shop, connecting to a loudspeaker in front. Interspersed between occasional musical selections came announcements of the day's delicacies. This proved so effective in producing sales that a rival butcher on the same block hailed him into court on a charge of unfair competition! The case was dismissed.

Keeping the Wolf from the Door

All of which reminds us of the fact that in certain parts of Russia, small villages, dotting a vast expanse of wild territory, guard themselves against attacks by wolves by frightening them away with powerfully amplified shouts emanating from loudspeakers on the outskirts of the villages.



PUBLIC ADDRESS APPARATUS

This particular panel by the Gates Mfg. Company of Chicago may be had as a portable job, and for permanent installations

As an Aid to Mind Reading

Most of us have at one time or another been amazed at the feats actually accomplished by the professional "mind reader." An assistant circulates among the audience. He stops and asks you your name and occupation. You whisper your replies so that the medium on the stage cannot possibly hear, and you are naturally astonished when the mind reader vibrates: "I feel the presence of a Mr. Smith. He is a radio serviceman, and is thinking of taking on public address systems as a sideline. He is wondering if he can make money at it. I have important advice to give him on this matter. See me after the performance."

And the mind reader can probably tell you plenty about the subject—the effectiveness of a small microphone concealed by the lapel of his assistant, and the utility of earphones concealed by the hair or turban.

Traveling Sound Trucks

This is one of the fastest-growing developments in the field. Many radio dealers and servicemen are equipping their delivery trucks with the necessary turn-table, microphone, amplifier and speaker. It is used for their own advertising when they travel around the streets in the course of daily business, as well as for renting time to other stores and enterprises. One operator, Bill Weinstein of New York City, has helped various auctioneers sell hundreds of thousands of dollars' worth of real estate with the use of his sound truck. The system is so easy to operate, that frequently Mrs. Weinstein and their fourteen-year-old daughter, Katherine, cover the entire job.

Of course the more general uses of P. A. systems are those with which we have been familiar for some time, and which have been described in previous issues of Radio News. Churches and auditoriums are perhaps the best customers of the serviceman. Public address systems are used in theaters for organist announcements, in hotels and camps for paging systems, in schools for communicating directly from the principal's office to the class-rooms, in swimming pools and stadia for announcing events, in railroad stations for train announcements, etc.

(Through the courtesy of the Wright De Coster Company, of St. Paul, Minn., we will be glad to send the radio serviceman, who writes in on his business letterhead, considerable published material on the various uses of P. A. systems, and place the serviceman on a free mailing list for future releases from this company. Simply address your request to Radio News, Department W.)

A Possibility for Restaurants

One of the Childs New York City restaurants has installed a system which greatly improves service. Instead of the waitresses running back and forth to the kitchen with every order, each waitress has a microphone installed close to her tables. All she has to do is to give her order into the mike which is connected to a loudspeaker in the kitchen.

Airplane Advertising

The sounds of music and voice coming from the sky is a familiar phenomenon in many cities and communities. It is produced by a simple public address system, readily installed permanently or temporarily, in any plane. Local picnics and outings are a good bet for this type of advertising.

The Institute of Radio Servicemen

This department has already made brief mention of the I. R. S. M., an association of servicemen with the betterment of the profession as its aim. The following statement of the purposes of the organization is by Ken Hathaway, formerly radio technical advisor to the Chicago *Daily News*, and now executive secretary of the Institute.

The Institute of Radio Servicemen is a non-commercial organization, incorporated, not for pecuniary profit, under the laws of the State of Illinois. The object of the Institute is to establish radio servicing as a profession; to aid radio servicemen through the distribution of technical information to supplement fundamental training; to devise ways and means of increasing financial return; to eliminate unethical practices; to encourage laws, rules and practices that will be for the best interest of the radio service profession, the radio industry and the public; and to protect its members in lawful and proper manner from injustices, impositions and fraudulent practices.

MR. K. A. HATHAWAY

Executive Secretary of the Institute of Radio Servicemen

It has long been known that men band themselves together for mutual protection and advancement. Persons associating together for the purpose of correcting common troubles develop a comradeship and understanding of each other that is beneficial to the group individually and collectively. The fraternal spirit is developed by contact, either by personal association or by the printed page. The Institute of Radio Servicemen is using both methods. The distribution of technical information is accomplished principally through the *Journal* of the Institute of Radio Servicemen. In effect, the *Journal* is to the radio serviceman what the *Proceedings* of the Institute of Radio Engineers is to the engineer.

The increase of financial returns, through the efforts of the organization, is inevitable. The members of the radio service profession who continually improve their knowledge of the art, will assume a status that is in accordance with the importance of their work, with a commensurate financial improvement. Also, the Institute has started plans, which, when completed, will enable the serviceman to handle additional products in the radio field through which he can increase his income.

The elimination of unethical practices entails the co-operation of the Institute of Radio Servicemen in securing information establishing the guilt of persons or organizations suspected of using methods not in accord with business ethics and which destroy the confidence of the public in the entire radio service profession.

News Items for The Serviceman

Consistent with the general utility of the serviceman in the sales and service of hearing aids, the Radio News Telephone Booster, described by S. Gordon Taylor in the February issue, is a logical item on his expanding shelf of merchandise.

There is one possible objection to the purchase of such a device which the serviceman is perhaps best able to overcome—namely, the fear on the part of the buyer that the telephone company may object to its use. There is a clause in most telephone contracts which prohibits the use, under penalty of service cessation, of equipment in

conjunction with the telephone, other than that made by the company. This rule, in many instances, is justified, for some equipment, not made to the standards of the Bell Company, falls down in service and ultimately result in repairs at the telephone company's expense. Also, in the case of a booster amplifier, the rule must be a very profitable one, for they charge $24 a year rental, which is almost exactly equal to the list price of the Booster described in RADIO NEWS!

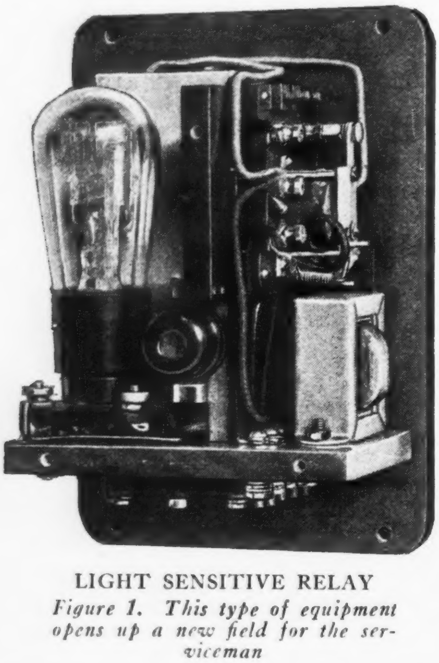
However, there are exceptions to every rule, and the Service Editor knows of no instance where auxiliary apparatus has been removed by the company when it did not definitely jeopardize service. The RADIO NEWS Booster is built to very high standards, and cannot, in any way, affect normal operation of the telephone. The chance that the lineman will report the use of such equipment, or that any objection will be taken to it, is so remote that the serviceman in charge of installation may safely guarantee the permanent use of the device.

Also, in many rural communities, where telephone service is supplied by a local company, definite official sanction of the device can in some cases be secured.

While on this subject of hearing aids, attention is called to Mr. Taylor's article in this issue, in which he describes the plan which RADIO NEWS has adopted to bring together the serviceman who are merchandising the RADIO NEWS Ear Aid (described in the January issue) and prospective buyers of this equipment. It is expected that this plan will be the means of providing many active sales leads to the servicemen who register their names in accordance with the invitation extended in the article referred to above.

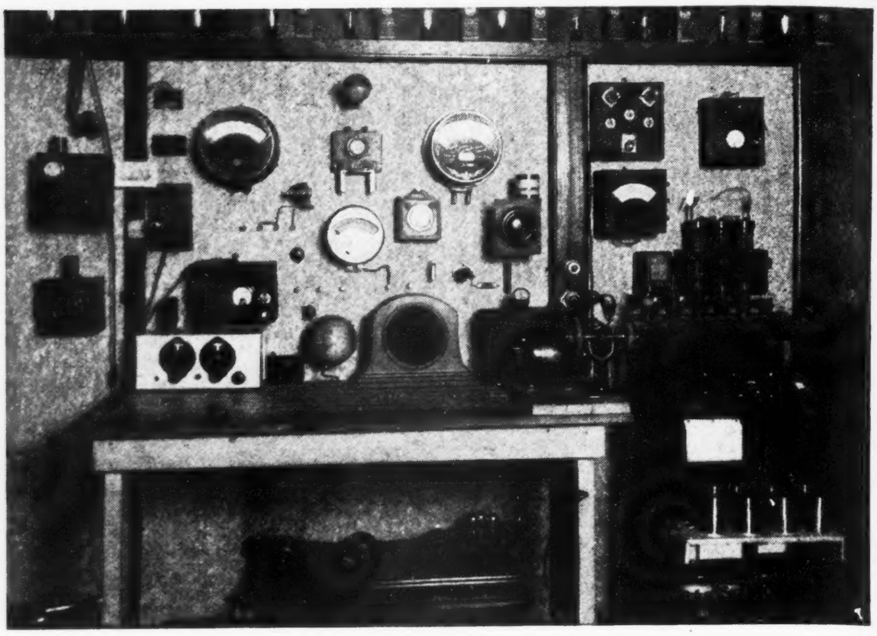
Photo-electric Relays

The wide and general utility of light-operated devices offers additional possibilities to the ambitious and alert serviceman.



LIGHT SENSITIVE RELAY
Figure 1. This type of equipment opens up a new field for the serviceman

While many of the uses to which photo-electric cells have been put, require highly complicated associated apparatus, the more simple systems may readily be installed by the radio expert. Among such are automatic lighting apparatus, which turns itself on at dusk, garage doors that open at night when the headlights of the car fall upon the light-sensitive cell, and a variety of ingenious burglar alarms which may be installed in buildings ranging from a bank building to a chicken coop.



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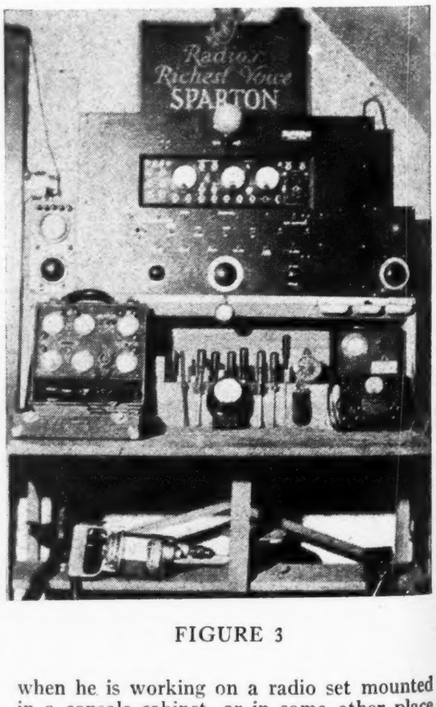

FIGURE 3

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(*Continued on page 892*)

¶ *Chatty bits of news on what is happening before the microphone. Personal interviews with broadcast artists and executives. Trends in studio technique.*

MILLS BROTHERS—VOCAL ORCHESTRA

Backstage *in* Broadcasting

***By* Samuel Kaufman**

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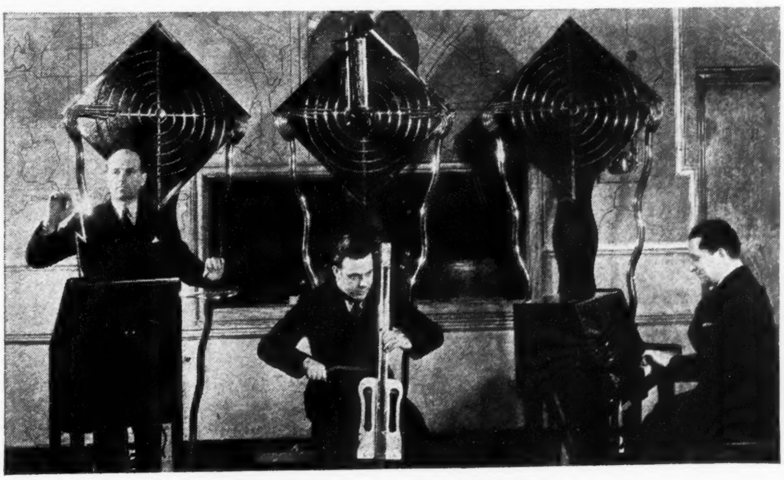
(*Continued on page* 895)

BILLY WALSH



THEREMIN ELECTRO-ENSEMBLE

WALTER WINCHELL

conjunction with the telephone, other than that made by the company. This rule, in many instances, is justified, for some equipment, not made to the standards of the Bell Company, falls down in service and ultimately result in repairs at the telephone company's expense. Also, in the case of a booster amplifier, the rule must be a very profitable one, for they charge $24 a year rental, which is almost exactly equal to the list price of the Booster described in RADIO NEWS!

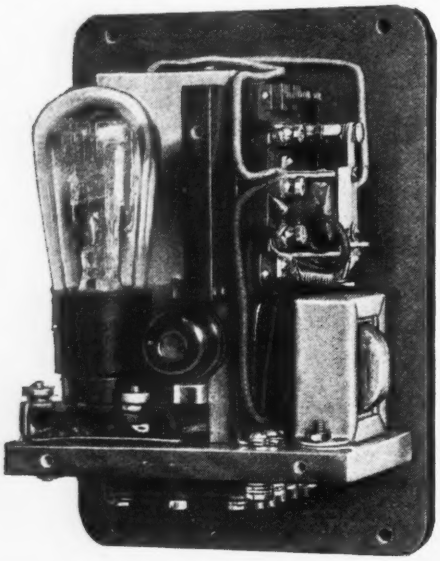
However, there are exceptions to every rule, and the Service Editor knows of no instance where auxiliary apparatus has been removed by the company when it did not definitely jeopardize service. The RADIO NEWS Booster is built to very high standards, and cannot, in any way, affect normal operation of the telephone. The chance that the lineman will report the use of such equipment, or that any objection will be taken to it, is so remote that the serviceman in charge of installation may safely guarantee the permanent use of the device.

Also, in many rural communities, where telephone service is supplied by a local company, definite official sanction of the device can in some cases be secured.

While on this subject of hearing aids, attention is called to Mr. Taylor's article in this issue, in which he describes the plan which RADIO NEWS has adopted to bring together the serviceman who are merchandising the RADIO NEWS Ear Aid (described in the January issue) and prospective buyers of this equipment. It is expected that this plan will be the means of providing many active sales leads to the servicemen who register their names in accordance with the invitation extended in the article referred to above.

Photo-electric Relays

The wide and general utility of light-operated devices offers additional possibilities to the ambitious and alert serviceman.



LIGHT SENSITIVE RELAY
Figure 1. This type of equipment opens up a new field for the serviceman

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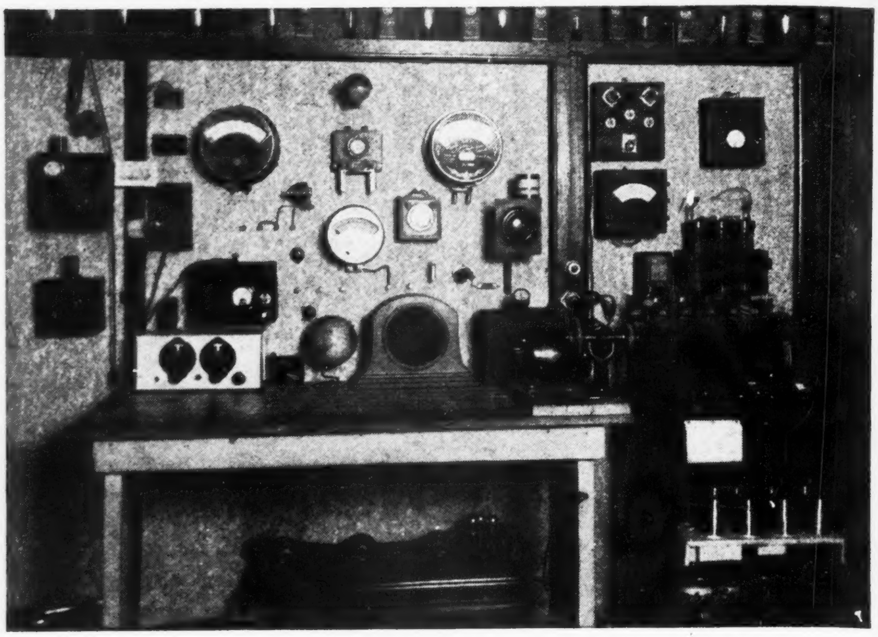

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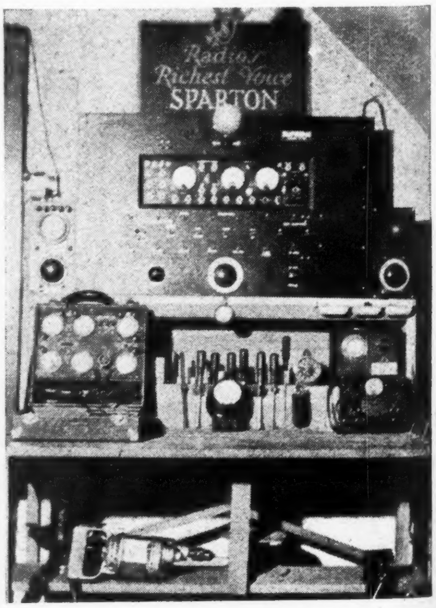

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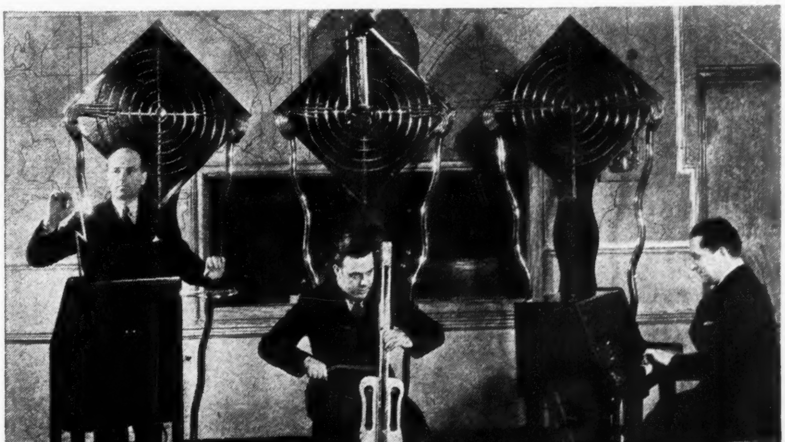


THEREMIN ELECTRO-ENSEMBLE

WALTER WINCHELL

With the Experimenters

Remote Control Device, Handy Holding Tool, Foolproof Speaker Plug, Smoother Regeneration Control, Indexing* RADIO NEWS, *Handy Forceps, Doctoring Dynamic Speakers, Condenser Lubrication, Pepping-up Phonograph Pick-ups, Warning on Static Reducer, Home-made Test Prods, Crystal Receiver

Conducted by

S. Gordon Taylor

Remote Control Device

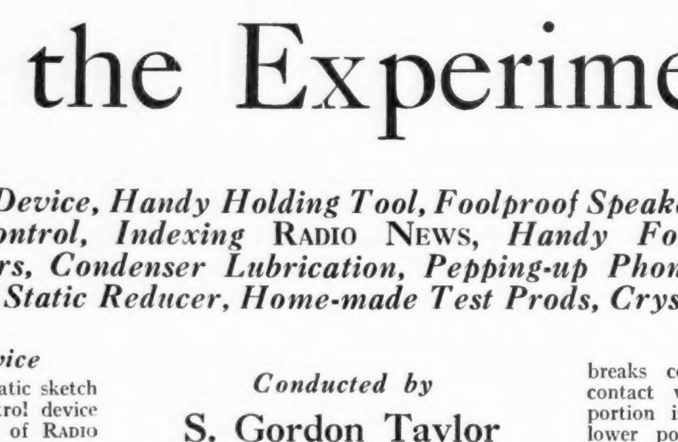
Herewith you will find a schematic sketch and description of a remote control device in which I believe many readers of RADIO NEWS will be interested.

To date the supporters of this method of remote control have been confronted with the problem of reversing the direction of rotation of the receiver dial by a simple means.

As you will see from the description, a simple and effective means is suggested for overcoming this difficulty.

R1, R2 and R3 are the fixed resistances of the Wheatstone bridge. R4 is a resistance equipped with a sliding contact which is attached to dial D. Thus, by merely moving the dial to either left or right, different values of resistance are obtainable.

The dial D is a special feature in itself. As seen in the diagram to the right, it consists of two parts built on a common shaft. The top portion, that which is clasped by the fingers when tuning, is so built that it has a "play" of about ¼ inch in order to enable it to make contact with either lead 4 (when rotating the dial to the right) or lead 2 (when rotating the dial to the left). The purpose is to make contact with only one lead at a time and be independent of the other. Thus when the dial is being turned to the right contact is made with lead 4 and that with lead 2 is broken. As the dial is further turned to the right, a sliding arm which is attached to the lower portion of the dial is caused to move over the resistance R4 and the resistance is increased. In the same way, when the dial is turned to the left the upper portion of the dial breaks contact with lead 4 and makes contact with lead 2, and as the upper portion is further turned to the left the lower portion is also forced to turn to the left and, consequently, moves the slide arm to lessen the resistance of R4.



The movement of the lower portion of the dial D is made possible due to the fact that the leads 2 and 4 are connected to the electrodes A and B, which are rigidly fixed to the lower portion and stick out about ¼ inch so as to enable the electrode C of the upper portion to push against either A or B, depending upon whether a turn is made to the left or right.

In practice the operator turns the dial D to a predetermined point; the resistance R4 is thus varied, and contact with one of the electrodes is made. A difference of potential across XY is the result and the relay is caused to close. The reversible motor then receives energy and therefore starts rotating in a direction dependent upon the lead with which contact had been made. Thus, when the dial is turned to the left, contact is made with lead 2 and the circuit is closed for rotating the motor to the left. In the same way, when the dial is turned to the right the circuit which causes the motor to turn to the right is closed. However, as the motor is started and rotates the tuning condensers of the receiver, it performs a null-adjustment by

(*Continued on page 895*)

Handy Holding Device for Small Work

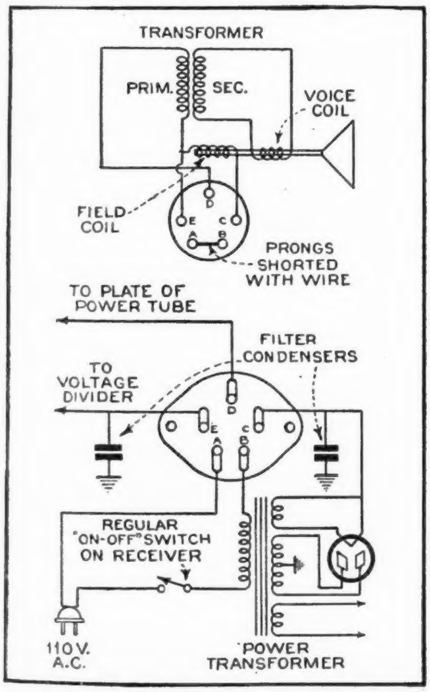
Thin flat parts or pieces which often need to be filed and brightened in repair work, are a very mean thing to hold in the fingers.

It is out of the question to grip many of them in any kind of a small hand vise or chuck. A very handy arrangement to have in the kit or around the bench for this work is shown herewith. Simply a new pair of the small rubber heels or heel tips for ladies' shoes, which can be procured in any dime store for a nickel. Any thin, smooth, flat piece can be safely laid in between them, easily and securely held with but little effort. Makes it comfortable and convenient to work on the part with any kind of a small file. The rubber pieces take up little or no room and can be handily used many, many times.

FRANK W. BENTLEY,
Missouri Valley, Iowa.

A Foolproof Speaker Plug

Many persons turn their set on when the speaker plug is not in its socket thus imposing a strain on filter condensers and other expensive parts. As this is a costly procedure, and I have a tendency to be absent-minded, I devised the arrangement shown in the diagram to protect my set against my carelessness. It is applicable to all sets having speaker plugs and sockets not using push pull speakers and the only parts required to make the changeover are a five-prong speaker plug and socket.



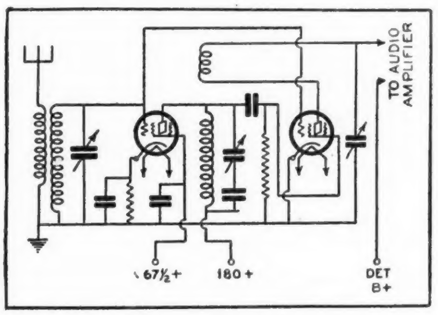
Many receivers use a four-prong speaker plug and socket and in many of these only three wires go to the speaker, two to the terminals of the field and one to the high end of the primary of the voice-coil transformer. The low end of the voice-coil transformer primary gets its voltage from one of the field leads and this connection is made at the rear of the speaker. If we change the four-prong outfit for a five-prong plug and socket we have two unused prongs which can be connected as a switch and wired in series with the primary of the power transformer. One of the 110 volt supply leads is cut and each end soldered to a filament prong on the new speaker socket. The filament prongs on the plugs are shorted. Thus when the plug is in the socket there is continuity in the primary of the power transformer and the set can play. This circuit is broken when the speaker plug is removed and it is impossible for the alternating current to flow thru the gap between the filament prongs to the power transformer, even if the set is connected to the 110 and the switch is turned on.

These changes are easily made by following the diagram.

ARTHUR B. COONEY,
Alhambra, California.

Smoother Regeneration Control

While experimenting with a Pilot Super Wasp I fell on the following simple arrangement which provided greater sensitivity and better control of regeneration.



The short-wave set was wired for a type -27 detector tube, but when using the -27 the tube did not slide into oscillation gently, but instead scraped in with a loud and all too sudden "plop."

By plugging a type -24 screen-grid tube into the detector socket and running a wire from the cap on the top of the tube to the cap of the radio-frequency tube as shown, increased sensitivity and greater volume were obtained with fine regeneration.

It is not claimed that this stunt will work in all regenerative circuits but it does work out with extreme satisfaction in the case of the Super Wasp receiver which I am using.

ALLEN D. RICKERT, JR.,
Souderton, Pa.

Indexing RADIO NEWS

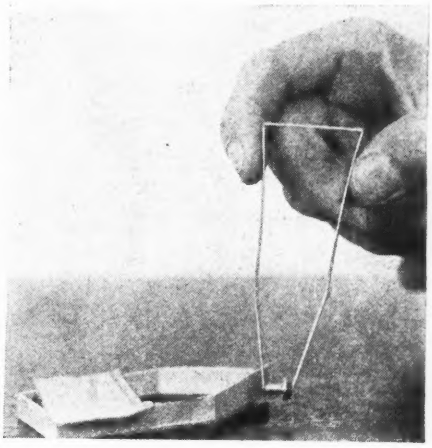
After reading through my copy of RADIO NEWS there are frequently articles to which I know I shall later wish to refer. In the past I have been pasting tabs on the edge of the cover but found that they kept tearing off. I have overcome this by pasting a small piece of paper, about 2½ inches by 5 inches, on the lower left-hand corner of the cover of each issue. On this paper I write the name and page number of the articles that particularly interest me in that issue. Later I can locate these articles easily and quickly.

This system has saved lots of time for me and it may be of interest to other readers as well.

C. W. BENTLEY,
Medford, Ore.

Handy Tool Made from an Ordinary Match Box

There is always some screw or other small machine part getting accidentally down into a place you cannot reach with the fingers or



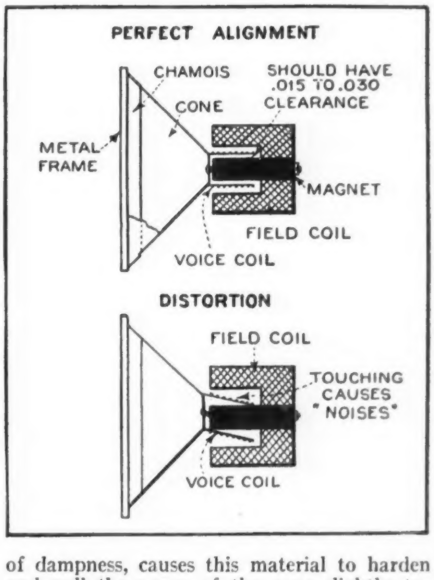
anything else handy to get it out. There is no end either to the clever practical devices made for such instances, but all of them depend on what is convenient to make them out of. The above photo shows a handy "pick up" made of the tray sides or slide portion of a common penny wooden match box. The piece which forms the tray or slide can be quickly "unwound" and forms an excellent pair of light springy forceps or tongs. The wood can be split with a knife to any desired width. You will be surprised at how easily they can be handled and at the grip or pinch you can get out of them at the business ends.

FRANK BENTLEY,
Missouri Valley, Iowa.

Doctoring Dynamic Speakers

Having made a careful study of dynamic speakers in use in the present-day radio sets, I have found that "rattles" and "noises" are often caused by changes in temperature and moisture of the air.

The diaphragm is usually securely held at the periphery or rim of the cone, with a ring of chamois skin, or some other similar substance. Warm weather, following a period



of dampness, causes this material to harden and pull the paper of the cone slightly towards the top or sides. Sometimes the paper itself, after absorbing moisture, becomes dry and distorted. Under strong vibrations while in operation, the centre of the

(*Continued on page* 894)

Question Box

PHYSICS and science instructors will find these review questions and the "quiz" questions below useful as reading assignments for their classes. For other readers the questions provide an interesting pastime and permit a check on the reader's grasp of the material presented in the various articles in this issue.

The "Review Questions" cover material in this month's installment of the Radio Physics Course. The "General Quiz" questions are based on other articles in this issue as follows: The "Twin-Grid" Tube, A Modern Quartz-Crystal Receiver, Latest Short-Wave Converter, With the Experimenter, Phenomena Underlying Radio, A 16.5 to 550-Meter "Super" of Radical Circuit Design, The March of Television, Radio Fever, Two New Tubes.

Review Questions

1. *Calculate the power supplied to the filament of a 280 type rectifier tube which takes a current of 2 amps. at 5 volts.*
2. *State the four factors upon which the resistance of a conductor depends and explain just how each one affects the resistance.*
3. *The diameter of 1000 ft. of No. 24 B. & S. copper wire, used for the winding on a filament transformer is .0201 inches. What is its diameter in mils? What is the circular mil area? If the specific resistance of copper wire is 10.35 at 20 deg. C., what will be the resistance of this wire at a temperature of 20 deg. C.?*
4. *What is the resistance of the wire in problem 3 at an operating temperature of 80 deg. C. if the temperature coefficient of copper is .004?*
5. *From the table of specific resistances of various materials in your book, write down the ten metals having the highest specific resistances. Next to each, write down how many times greater its resistance is than that of annealed copper.*
6. *Describe the construction of the vitreous enameled type of wire-wound resistor.*
7. *Describe the construction of two forms of high resistors used in radio receivers in places where very little current will be flowing.*
8. *Describe the construction of a variable high resistor designed to carry a small amount of current without overheating. What is the purpose of the flaked mica in this?*
9. *Describe the construction of a variable wire-wound resistor.*
10. *What installation conditions affect the power in watts which a resistor can dissipate?*
11. *Draw a symbol for (a) a fixed resistor, (b) a variable resistor, (c) a resistor tapped at the middle, (d) a resistor tapped at three places.*

General Quiz on This Issue

1. *How do strong ultra-short radio waves affect the human body?*
2. *What is a harmonic generator?*
3. *What is the electrophorus?*
4. *What does the term "definition" mean as applied to television? Why is it important?*
5. *The use of a quartz-plate circuit in a superheterodyne i.f. amplifier admittedly attenuates the higher audio frequencies. By what method is this attenuation overcome in the latest design of receivers of this type?*
6. *Explain why a Stenode receiver tends to reduce background noise.*
7. *How are the grids placed, in one of the newest tube designs, to make the tube characteristic identical when either grid is in the circuit?*
8. *Why does this tube lend itself particularly well to automatic volume control?*
9. *What forces or conditions may upset the normal balance of charges in the atom?*
10. *What are the advantages of incorporating one i.f. stage in a superheterodyne type short-wave converter?*
11. *What principle, commonly used in measuring resistance, is employed in one type of simplified remote control, and how is this principle utilized?*
12. *How may signals of high frequencies be converted to signals of lower radio frequencies?*
13. *How may two ribbons of silk be made to generate 1,000,000 volts?*
14. *What are the advantages of the r.f. pentode tube?*

The Radio

This series deals with the study of the information of particular value to colleges. The Question Box aids

***By* Alfred A.**

SINCE the temperature of a conductor may be changed by the weather conditions or by the heat developed in the wire itself due to the passage of current through it, the temperature must be taken into account when calculating the resistance if accurate results are desired. The resistance of pure metals and most alloys *increases* as the temperature *rises.* The resistance of carbon and electrolytes (fluid conductors) decreases as their temperature rises. The amount of change of resistance varies with the different conductors, but for pure metals the increase in resistance is nearly .4% for each change of one degree Centigrade.

Manganin is an alloy of 84% copper, 12% nickel and 4% manganese, developed especially for use in the shunts of ammeters and for precision resistances. Therlo is a similar alloy. Its change in resistance per degree is one part in 100,000. "Constantin" is another alloy whose resistance does not change materially. It consists of approximately 60% copper and 40% nickel. It is used in rheostats and measuring instruments.

The amount in *ohms* that a piece of the material having a resistance of *one ohm* changes for each change of one degree in temperature is known as the *temperature coefficient of resistance* ("a"). Thus if a conductor has a resistance of one ohm at 20° C. temperature, it will have a resistance of one ohm plus the amount equal to this coefficient at 21° C. At 19° C. it would have a resistance of one ohm minus the coefficient, etc.

The average temperature coefficient between 0° and 100° C. and 32° and 212° F. is roughly the same for all pure metals and is about .004 per degree Centigrade, or .0023 per degree Fahrenheit (since one degree C. represents a larger change in temperature than one degree F.).

The temperature coefficient for annealed copper is .00210 at an initial temperature of 68° F. (on the Fahrenheit scale), or .00377 at an initial temperature of 20° C. (on the Centigrade scale). The value of the temperature coefficients of the various resistance alloys used in radio work for winding fixed or variable resistors must be obtained from the manufacturers of the resistance wire in any case when exact calculations are to be made.

Since the specific resistance of the conducting materials is usually given for the material at standard temperature of 20° C., the formula must be altered if we are to take into account the change of resistance due to the fact that the conductor may be at a temperature above or below 20° C. in actual practice. To calculate the true resistance of any metallic conductor at any temperature (up to 100° C.) use the formula

$$R = \frac{kL}{C.M.}[1 \pm (a \times t)]$$

where R = resistance of the conductor in ohms at operating temperature.

k = specific resistance of the conductor at 20° C.

L = length of conductor in feet.

C.M. = cross section area of conductor in circular mils.

a = temperature coefficient of the material per degree C.

t = difference in degrees between the operating

*Radio Technical Pub. Co., Publishers Radio Physics Course.

Physics Course

Lesson Nine
(Continued from Lesson Eight)

Resistances in Radio, Resistance alloys, How the resistance units are actually made and used

physical aspects of radio phenomena. It contains physics teachers and students in high schools and teachers in laying out current class assignments

Ghirardi*

temperature and the standard temperature at which the specific resistance k is specified (20° C. in most cases).

The ± sign inside the bracket means that if the temperature of the conductor is above the standard of 20° C. the resistance increases so the *plus* sign is used. If the temperature is below 20° C. the resistance is less and the minus sign is used.

Example: A piece of No. 18 B. & S. gauge copper wire 600 feet long is wound up to form a circular field coil for an electro-dynamic loudspeaker. When the normal current flows through the coil its temperature rises to 60° C. What is the exact resistance of the coil during normal operation?

Solution: From the copper wire table we find that a No. 18 wire has a cross-section area of 1620 circular mils. The specific resistance of annealed copper is 10.35 at 20° C. Its temperature coefficient is .00377 per degree C. "t" in the formula is therefore equal to $60 - 20 = 40$ degrees. Substituting these values, we obtain

$$R = \frac{kL}{C.M.}[1 \pm (a \times t)] = \frac{10.35 \times 600}{1620}[1 + (.00377 \times 40)]$$

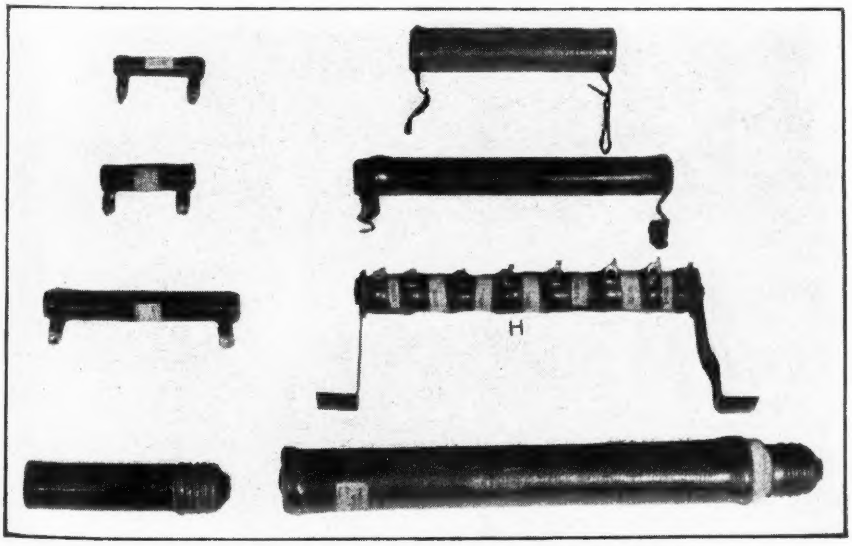
from which $R = 4.37$ ohms. Ans.

Resistors in Radio Equipment

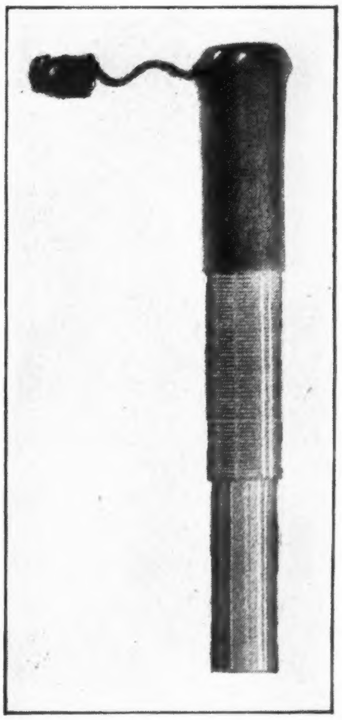
There is naturally a certain amount of resistance in every electrical circuit due to the resistance of the connecting wires, joints, contacts, etc. The resistance of a circuit can be kept low by making it as short as possible, using a good electrical conductor (such as copper), and making its cross-section area large. (Due to the fact that very high frequency currents travel only through a thin surface layer of the wire, *"skin effect,"* wires for conducting this type of current are often made up of a number of very small conductors insulated from each other by an enamel, cotton or silk covering. This is called Litzendraht wire.)

In radio equipment resistance is purposely introduced at various places in the circuits in order to reduce or control the amount of current flowing, reduce the effective voltage applied to a device, or cause differences of potential which are utilized for some definite purpose (C bias resistors), etc. A *resistor* is a device whose purpose is to intentionally provide resistance in an electrical circuit. Resistors may be made either fixed or adjustable (variable). *Fixed* resistors are those whose value cannot be changed readily while in use. *Adjustable* resistors may be varied in value. Fixed resistors are used in the filament circuits of battery-operated vacuum tubes, in the voltage dividers of B eliminators, for leaks, resistance couplings, for furnishing grid or C bias voltages, etc. Variable resistances are not used as much in radio receivers nowadays as they formerly were, due to the tendency to eliminate as many control knobs from the panels as possible. They are still employed as rheostats, potentiometers, volume controls, etc.

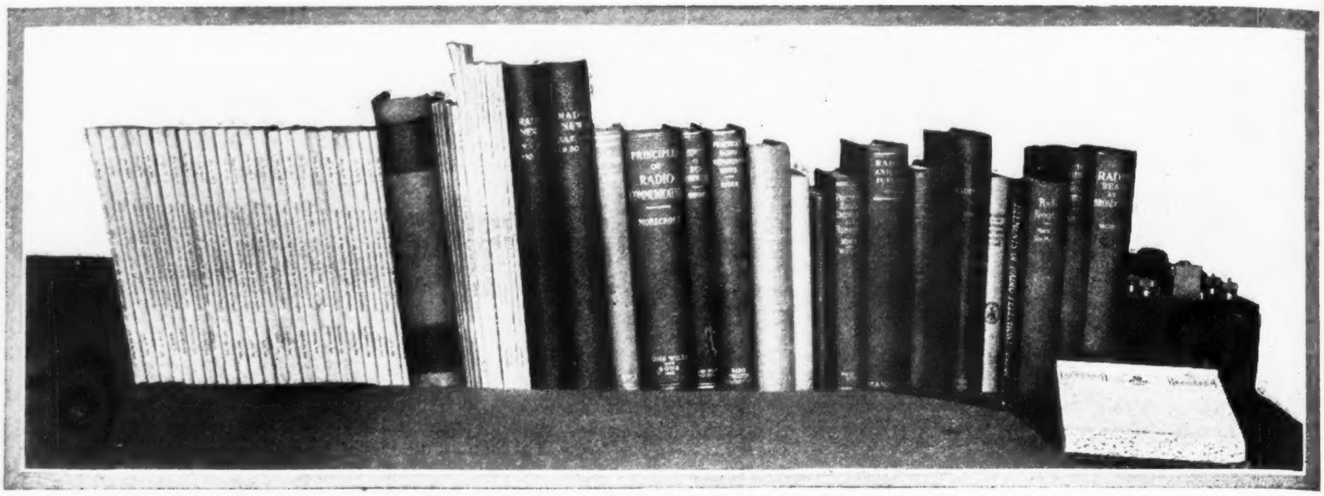
Vitreous enameled resistors are used extensively in power packs of radio receivers. They are made by space-winding the resistance wire on a special porcelain tube base. The base, including the terminal connections, is then coated with a powdered glassy enamel and fired at red heat. The result is a resistor unit covered with a vitreous enamel coating which protects the fine resistance wire from mechanical injury and serves as an excellent heat conductor to rapidly conduct the heat from the resistive element to the outside surface. This construction permits the finest resistance wire to be used without danger of oxidation or other chemical depreciation. The enamel also holds the resistance wire in place without any mechanical strain, (*Continued on page* 893)



WIRE-WOUND RESISTORS OF VARIOUS TYPES
Figure 2. Here are shown several forms of resistors of the vitreous enamel types, the smaller ones with screw terminals attached. The two lower resistors are equipped with the standard Edison lamp socket bases. At right, second from top, is a completed resistor similar to that shown in Figure 1. The resistor H contains a number of taps that make it suitable for voltage divider work. It is equipped with mounting legs



VITRIFIED RESISTOR
Figure 1. Shows the stages in building up this form of resistance. At the bottom is the porcelain tube upon which is wound a resistance wire shown at center. At top is the enamel coating which is then baked on after the terminal has been attached



Radio Science Abstracts

Radio engineers, laboratory and research workers will find this department helpful in reviewing important current radio literature, technical books and Institute and Club proceedings

Conducted by
Howard Rhodes

Radio and Electronic Dictionary, by Harold P. Manly. Published by Frederick J. Drake and Company. This book will appeal to experimenters, service men, amateurs, and others who sometimes find magazine articles somewhat confusing because the exact meaning of certain terms is not entirely clear. In such cases, this book will be helpful since it contains definitions of all the terms that are generally used in the fields of radio, television, sound pictures, and general electricity. The definitions are all arranged alphabetically and cross-indexed, so that definition of a particular word or phrase may readily be found. Where necessary, the definitions are illustrated to make their meaning entirely clear.

Since the book has just recently been published, it will be found quite up-to-date, including definitions of the essential terms used in the various fields mentioned above. The book does not aim to describe, in any great detail, how a particular device operates, but it does define a device and does give a general idea of its purpose. For example, under "series resonance" we find the following definition:

"The condition in a circuit which contains capacity and inductance in series, the values of the two being such that they produce resonance at the frequency of the applied voltage. The impedance to current flow is minimum, since the inductive reactance and capacitive reactance balance and leave only the circuit resistance. The current is in phase with the applied voltage."

From the above description and sample definition, the reader will be able to appreciate the scope of the book and what it aims to supply to the reader. The information for the book has been obtained from a number of well-known sources such as the Bureau of Standards, Institute of Radio Engineers, and various other magazines.

Radio Receiving Tubes, by James A. Moyer and John F. Wostrel. Published by McGraw-Hill Book Company, Inc. This is the second edition of this book, the present revision being necessary because of the development of new types of tubes and changes in the design of tubes already in use. The book also includes more complete descriptions of apparatus required for radio-receiving sets and industrial equipment; the scope of the text has also been enlarged to include allied fields, such as surgery, in which tubes have found considerable use.

In this book the essential principles underlying the operation of vacuum tubes are described in a manner designed to give information that will prove useful to students and others whose work is concerned with the application of tubes to various purposes. To those who feel that tubes are only used in radio sets, the book should prove quite informative, since it describes applications of tubes to the remote control airplanes and sea-going vessels as well as methods of applying tubes to the control of humidity, temperature, and other purposes. Most of the data on these subjects is included in the latter chapters. The major portion of the book is concerned with the fundamental principle of all tubes and methods for checking their characteristics.

The book includes many excellent curves and diagrams, giving actual data on tubes and circuits in which they are used. The book contains little mathematics, but the authors have not hesitated to use it where it was essential to clearly illustrate some significant characteristic of tubes.

In comparison with the first edition, we feel that this revised edition shows considerable improvement. The authors have added a quantity of data of a practical nature which makes the book more definitely helpful to the average reader.

Review of Articles Appearing in the February, 1932, Issue of the Proceedings of the Institute of Radio Engineers.

Frequency Stabilization of Radio Transmitters, by Yuziro Kusunose and Shoichi Ishikawa. This paper discusses in complete detail the various methods of stabilizing the frequency of oscillators. Not only is the theoretical basis of the various methods of stabilization described in detail, but practical information on the actual results obtained, using the various methods, is also given.

The following methods of stabilization are described in the greatest detail and the authors state that they may be applied to an oscillator to obtain a frequency stability in the order of 0.01 per cent:

(a) In an ordinary self-oscillator, the effect of the variation in the supply voltage may be minimized by the following means: two methods have been developed, a resistance-stabilized oscillator and a phase-compensated oscillator.

(b) Quartz stabilized oscillator. In this method, a quartz crystal is introduced in the grid circuit in such a manner that it is very loosely coupled to the oscillator, but still retains its stabilizing function. Oscillator power outputs up to one hundred watts or more can be obtained and thus the number of stages of radio-frequency power-amplification can be reduced.

(c) Mechanically stabilized oscillator. A vernier condenser, mechanically driven and controlled by a relay, is connected to the oscillator circuit. A quartz oscillator is used as a frequency standard and the relay is actuated by the beat frequency which controls the rotation of the vernier condenser so as to counteract the frequency variation. Thus a high-power oscillator can be directly stabilized by a low-power quartz oscillator.

(d) Valve stabilized oscillator. A valve is coupled to the oscillator in such a manner that it acts as a pure capacity and the effective capacity is controlled by the grid-bias voltage. A quartz resonator is used as the frequency standard, and its resonance characteristic is utilized to control the grid-bias voltage of the valve so as to stabilize the oscillator frequency. This method can also be applied to the control of high-power oscillators.

In connection with these various methods of stabilization, the authors give curves showing the effect on the oscillator frequency of variations in the supply voltages. For most of the experiments, the authors

used common types of tubes such as the 201-A, 112-A, and 171-A. Many of the curves indicate the degree of stability obtained to be extremely good. It will be realized by readers that these methods can be applied not only to ordinary transmitters but to any circuits using radio-frequency oscillators, where constancy of frequency is essential.

Battery Design Problems of the Air Coil Receiver, by F. T. Bowditch. This paper deals with the design features of battery-operated radio sets which are important from the standpoint of obtaining maximum useful battery life. This problem is one of arranging the receiver design so as to make it most adaptable for use with the air-cell type of A battery. The paper indicates the desirability of arranging the circuit so that good performance is obtained, even though the B battery voltages drop.

Quartz-Plate Mountings and Temperature Control for Piezo Oscillators, by Vincent E. Heaton and E. G. Laphan. If the maximum degree of frequency stability is to be obtained from the quartz-crystal oscillator, it is essential not only that the temperature be accurately maintained, but also that the crystal be very carefully mounted. Unless the movement of the quartz plate in its holder is restricted, the frequency will change with each slight jar. The authors describe a satisfactory holder for mounting long rectangular quartz plates to vibrate in the direction of their length, which consists of clamping the plate between two keys along a central line perpendicular to its length. A plate mounted in such a holder will be constant in frequency to within one part in three hundred thousand. A mounting for a cylindrical quartz plate, for "thickness oscillation," may be made by clamping the plate between three screws, mounted 120 degrees apart, so that they press into a V shape groove cut around the cylindrical surface of the plate, midway between the faces. Such a plate and mounting have been found to give a frequency stability of one part in 1,000,000, provided temperature control is used.

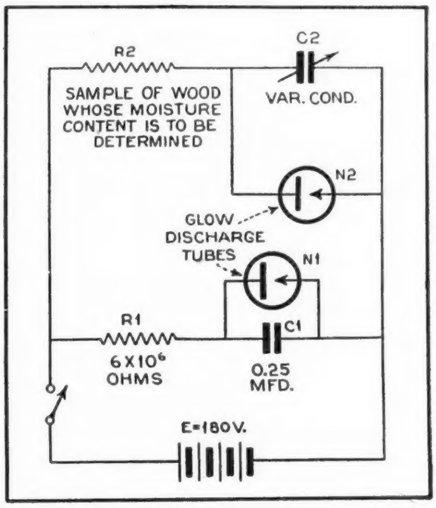
Elimination of Harmonics in Vacuum Tube Transmitters, by Yuziro Kusunose. A simple method is given for eliminating the strongest harmonic produced by an oscillator in which a parallel resonant circuit, having a resonant frequency slightly lower than that of the harmonic to be eliminated, is connected to the plate circuit and coupled to the main oscillatory circuit. The paper gives experimental data on the results obtained using this system. It also gives a brief resume of the present state of technique concerning the suppression of harmonic currents in oscillator circuits.

Characteristics of Airplane Antennas for Radio Range Beacon Reception, by H. Diamond and G. L. Davies. The investigations described in this paper were undertaken with the idea of determining whether an antenna arrangement could be devised which would have all the desirable electrical properties of a vertical pole antenna and yet be free from the mechanical difficulties encountered in the use of this type of antenna. It was found that the symmetrical transverse T antenna and the symmetrical longitudinal T antenna with vertical lead-in portions, give the desired properties. These antennas, when used with radio beacons, do not show any "course" errors and give the same received voltage as a vertical pole antenna having a much greater actual height. The paper also gives a theoretical treatment which enables the voltage, induced in the antenna, to be calculated; the voltages, calculated theoretically, were found to check closely with those found in practice.

Review of Contemporary Periodical Literature.

Cathode-ray Oscillograph Timing Axis, by F. T. Brewer. Electronics December, 1931. The author describes a method of applying a timing wave to a cathode-ray tube which involves the use of a condenser-discharge circuit. In order that the time axis may have linear characteristics, only a small portion of the condenser discharge curve is utilized; over this small range, the discharge can be considered to be linear.

Audio-frequency Compensation Methods, by Julius G. Aceves. Electronics December 1931. This article, taken from a chapter on audio-amplification which forms part of a Handbook for Radio Engineers to be published by the McGraw-Hill Publishing Company, discusses circuits to obtain various audio-frequency characteristics, especially with the idea of re-inforcing the high frequency. A number of circuits are given, together with curves showing the characteristics obtained.



A New Selenium Tube, by G. F. Metcalf and A. J. King. After many years of neglect, we find selenium again coming to the fore as a light-sensitive material, useful in applications where constancy of output with frequency is not important; more specifically, the selenium tube is found to be especially useful in "on-off" types of light-control circuits. This selenium tube, a development of the General Electric Company, is known as the type FJ-31. It has the following characteristic:

Average resistance at 100 foot-candles .... .75 megohms
Average resistance in dark.. 6.0 megohms
Maximum voltage a-c. or d-c.....125 volts
Maximum current .... 0.5 m.a.

The selenium cell can be used either with vacuum-tube amplifiers and relays, or, can be used to control thyratron tubes. As a matter of interest, the authors show the frequency characteristic of the tube, which indicates a response at 7000 cycles approximately one-fifth as great as the response at 500 cycles.

A New Oscillator for Broadcast Frequencies, by O. M. Hovgaard. Bell Laboratories Record, December, 1931. This article describes the new type of quartz-crystal oscillator, developed by the Bell Laboratories. In this new oscillator, the quartz plate is clamped between electrodes having, on their surfaces, a number of small raised portions; physical contact between the quartz and the plates is affected by these raised portions. This construction prevents movement of the quartz plate and changes in spacing are made insignificant, due to the many slight air gaps obtained by this construction. The entire unit is mounted in a temperature-control box. Curves are given showing the results obtained from this new oscillator and the old type oscillator. They indicate that the new oscillator is some fifteen times better than the old type.

Determination of the Moisture Content of Wood by Electrical Means, by C. G. Suits and M. E. Dunlap. General Electrical Review, December, 1931. This article is reviewed not with the idea that the moisture content of wood is of prime importance to radio engineers but with the idea that the method used might suggest other uses to which the system could be put. Tests on wood have indicated that the resistance varies greatly, depending upon the moisture content. For example, if the resistance of Douglas Fir is checked by means of pins driven into the wood one inch apart, it is found that the resistance is in the order of 25,000 megohms, with a moisture content of 7 per cent.; with a moisture content of 20 per cent., the resistance drops to about 2 megohms. The rapid change in resistance with humidity makes it possible to check the humidity accurately by measuring resistance. For this measurement, the author devised a circuit using glow tubes, arranged as indicated in the circuit of Figure 1. By adjusting the condenser C-2 until the tube N-2 flashes at the same rate as N-1, the percentage humidity can be determined, the dial of C-2 being calibrated in terms of percentage moisture.

The Public Address and Radio Program System in the Waldorf Astoria Hotel, by Robert C. Sturgeon. Projection Engineering, January, 1932. This article gives a good technical description of the public address and radio system in this hotel, which makes it possible to supply six different programs to each of some two thousand rooms. Programs can also be reproduced through loudspeakers located in the various public rooms through the hotel. Outlets into which microphones can be connected are placed at various points. These outlets permit the use of condenser-type microphones with built-in amplifiers, plate and filament voltages being supplied at the outlet. A centralized antenna system, located on the roof, connects to 140 suites so that permanent guests may install their own radio receivers.

Curves and circuit diagrams are given on the complete circuit. The radio receiver used to pick up programs is of the tuned-R.F. type with a sensitivity of 2.5 microvolts-per-meter. The overall characteristic is *down* about 3 db at seven thousand cycles.

Sound Absorption Balance in the Acoustics of Auditoriums, by V. A. Schlenker. Projection Engineering, January, 1932. A rather complete article on the acoustics of auditorium with reference, particularly, to reverberation times and methods of test. Oscillographs are given showing the sound decay under various conditions of absorption. The article is especially good in that it includes a great many actual quantitative figures and discusses the entire subject in a practical and useful manner.

The Recording and Reproducing of Sound, by A. G. D. West. Journal of the Royal Society of Arts, England, November 6th, 1931. An extremely good article on the subject of sound recording and reproduction. The author discusses desirable frequency ranges and the extent to which they can be approached in practice. Curves are given on various types of transformers, some of which show characteristics essentially flat from about 30 cycles up to 30,000 cycles.

News *and* Comment

A page for the news of the whole radio industry, including important trade developments, new patent situations, comments by leading radio executives, notes, rumors and opinions

Reported by

Howard S. Pearse

Every Other Home Has Radio

WASHINGTON, D. C.—Practically every other home in the United States now has a radio. That is the conservative deduction drawn from the U. S. Census Bureau's census of radio, which shows that 12,078,345 of the 29,980,146 homes in this country, or 40.3 per cent, had radios when the count was made as part of the decennial census of population of April 1, 1930. With 4.1 persons in the average American family, the total audience as of that date, 23 months ago, was 49,521,214.

In the 23 months that have elapsed since the census was taken, the radio trade estimates that at least 4,000,000 radios were sold, mostly midget sets and mostly to homes that never before had radios. This would bring the total for the country to well over 16,000,000, or well beyond the 50 per cent mark. It would indicate an audience that numbers around 65,000,000.

Television on Light Beam

SCHENECTADY, N. Y. — Television, transmitted experimentally on a beam of light, utilizing a wavelength of but a billionth of a meter, has been successfully demonstrated here in the radio consulting laboratory of the General Electric Company, it was announced recently by Dr. E. F. W. Alexanderson. This use of the ultra short waves, Dr. Alexanderson believes, opens the way to a new and valuable era in the art and promises to result in more distinct television pictures.

Today's Radio Dollar

CHICAGO—The radio dollar of today has three times the purchasing power of two years ago and nearly ten times as much as five years ago, J. Clarke Coit, president of the U. S. Radio & Television Corporation, manufacturer of U. S. Apex and Gloritone sets, asserts on the basis of a compilation of comparative costs, plus the new innovations and higher efficiency incorporated in the modern receiver.

Part of the increased value of the radio dollar is due to lower costs of materials and lower production costs due to increased manufacturing efficiency, and the balance of it lies in the many scientific advancements achieved by radio engineering, Mr. Coit stated.

Radio Amateurs Increase

WASHINGTON, D. C.—Intensified interest by American amateurs in radio transmitting is disclosed in the annual report of W. D. Terrell, director of the Commerce Department's radio division. During the last year, the report shows, the number of licensed amateur radio stations rose to 22,739, an increase of nearly 4,000 as compared with the preceding year. It is apparent from this figure, it is pointed out, that amateurs are by far the largest users of transmitting radio stations in the United States. Accompanying the increase in amateur stations was a nuoticeable increase in the number of inquiries received in the division from amateurs. The growing use of radio-telephone by amateurs, it is believed, accounts for this unusual interest.

British Publish World Radio Reception Chart

LONDON, ENGLAND — Calibration charts designed to "enable the least technically minded of listeners" to identify practically all broadcasting stations within tuning range of their receiving sets have been published and made available to radio fans by the British Broadcasting Corporation. The booklet is titled "World Radio Calibration Charts" and costs the listener one shilling.

A statement by the BBC, which published the charts fully realizing that they might help detract listeners from its own programs, says that the majority of those who listen to foreign stations tune in those stations on no fixed principle. The booklet not only contains graphs and logs of the long and short wave stations that can be heard in the British Isles, but tells how they can be identified and gives their average reception strength in Great Britain.

European Television Research

BOSTON—"Europe is working steadily if quietly on television with progress paralleling the work of American research," states Alexander Nyman, consulting engineer of the Shortwave and Television Corporation, who has just returned from an engineering trip abroad which took him through Switzerland, Berlin, Finland, London, and Paris. "Both the mechanical and cathode ray systems have their own advocates as in this country and both are making interesting progress.

Future "Home" Theatres

CAMDEN, N. J.—Drawing aside, for an instant, the veil of secrecy that hangs over the great radio laboratories here, W. R. G. Baker, vice-president of the RCA Victor Company, in a recent interview permitted a brief glimpse at the radio marvels of the future which scientists are creating there.

The day is in sight, said Mr. Baker, when every new home costing $10,000 or more will have a room somewhere fitted up exclusively for radio-electrical entertainment. The "Home Theatre" will become another American institution. Television and home talkies will share room with a radio news bulletin, and talking books, that read themselves aloud to those who wish to save their eyes.

Radio Sales Tax Being Considered

WASHINGTON, D. C.—A federal sales tax on radio receiving sets to aid in bolstering the nation's depleted revenues, is under consideration by the Treasury Department, and may be proposed to Congress in the new internal revenue schedule.

With several million sets sold annually, internal revenue experts have decided that a small tax on set sales would yield substantial revenue and yet not be felt either by the public or the industry. They are inclined to classify radio as a semi-luxury, like jewelry, automobiles, and confections, and in these times, when the Treasury faces a deficit estimated at $2,000,000,000 for the current year, it is deemed desirable to levy an excise duty of this nature. Congressional action, of course, is necessary.

A sales tax, it was emphasized at the Treasury, is not to be confused with a license tax on receiving sets. There is no thought of levying annual license fees, as is done in most every other country to defray the costs of maintaining the governmentally-operated systems. If adopted, the tax here simply would be on the retail price of the new set.

Radio Blamed for Drought—Now for Too Much Wetness

GENEVA, SWITZERLAND—Echoes of the day not long ago when certain self-selected soothsayers blamed the drought on radio waves and asked the U. S. Weather Bureau to declare a moratorium on all radio transmission have been heard by the League of Nations. Some one has written to the Geneva body here, asking that all European broadcasting be stopped for five or six weeks to determine whether radio is responsible for the prevailing wet weather. The signer of the letter urged the appointment of a "competent commission" to make observations of the climate conditions during the radio-less lull and then to publish a report that would either condemn or acquit the radio waves.

Press Wireless Concession

PARIS, FRANCE—Press Wireless, Inc., cooperative radio news distributing subsidiary of a group of American newspapers, has been authorized by the French government to erect a transoceanic radio station near here, in return for which it has agreed to make available its Hicksville, Long Island, transmitting station for service to the press of France.

Giant 500-Kw. Tube in London Display

Exceeding even the giant six-foot tubes used by KDKA, Pittsburgh, in testing radio powers up to 400,000 watts, the highest ever used in broadcasting, is the 500,000 watt tube that has been constructed for the British Post Office Department's transatlantic station at Rugby. Described as "a continuously evacuated valve," the British tube, a giant counterpart of the ordinary receiving set tube, but used only for high power transmitting purposes, is said to be the largest in the world. It was recently displayed at the Faraday Exposition in London by the Metropolitan-Vickers, Ltd., its manufacturer.

Japanese Radio Monopoly Building Seven New Stations

TOKYO, JAPAN—Plans for the construction of seven new broadcasting stations to widen the service being furnished by the 15 existing stations of the Japan Central Broadcasting Corporation have been approved by the Japanese Department of Communications, according to a report from the Assistant American Trade Commissioner at Tokyo, H. B. Titus.

(*Continued on page 896*)

Radio Fever

(Continued from page 834)

to the heating effect of different frequencies under various conditions.

For the mathematical determination of the heating of a body of primarily dielectric properties it has been found that it depends primarily from the composition of the electrolyte, from its concentration, from its size and form and from the wavelength.*

According to the classical field theory of James Clerk Maxwell, the characteristic wavelength of a body is determined by

$$\lambda = \frac{\varepsilon}{2x} \qquad (1)$$

Hereby λ the wavelength, ε the dielectric constant and x the conductivity of the substance. Taking the reciprocal value of equation (1), we derive the following expression:

$$\frac{1}{\lambda} = \frac{2x}{\varepsilon} \qquad (2)$$

In introducing in this equation (2) specific data, Paetzold† gave the following formula as an expression for the wavelength under which a body might expect its strongest heating effect:

$$\frac{c}{\lambda} = f = \frac{2g}{\left(1 + \frac{4\pi l}{aqk}\right)} \qquad (3)$$

where f = the frequency (reciprocal to the wavelength)
g = the conductivity of the substance (the same as x)
l = the length of the body
q = the cross-section of the body
a = reciprocal expression of the various equivalent capacitances involved in the ararngement
k = the dielectric constant of the body (the same as ε)

This means that the characteristic frequency for a substance has to be high if the dielectric properties of the substance are small. The frequency will be lower if the substance has a minor electrical conductivity.

Biological Applications

There are many other biological applications possible and it may be expected that the radio sciences will open up a much wider field in influencing biological tissues than thought of today. For instance, an experiment has been made in Italy, where caterpillars of the silkworm were exposed to ultra-high-frequency fields. All of these silkworms hatched sooner and gave more silk than the untreated ones. However, this treatment is still too expensive today for practical use.

One of the interesting experiments which have been made with this ultra-short-wave generator was to place flies in a glass body contained in ice. Ordinarily these flies died after a very short period of time. If, however, subjected to the influence of the radiothermic oscillations, the flies continued to live in between the ice blocks. At a later date rooms might be heated with a radiothermical process, using no caloric heat production but having the temperature raised in the body as induced by its dielectric properties in the field of high-frequency oscillations. At both ends of a room wires or metal plates might be built in in the walls, filling the space between them with high-frequency energy and thus heating up the persons in the room between the plates.

The application of radio transmitting apparatus for the science of medicine promises to be a valuable tool in fighting disease. The application of radio waves, beginning with

(Continued on page 874)

Aviation Radio Game

(*Continued from page* 831)

than a ship's operator. He is *worth* more.

To get a job in aviation as a radio maintenance man you should be a good trouble-shooter on aircraft sets, a good battery man and not averse to gassing and oiling planes. Occasionally a maintenance man will be required to relieve the airport radio operator, which means that he should know the company's communication system as well as its sets. The most important thing is to be absolutely reliable and also adaptable to other kinds of jobs. When you "OK" a plane set, it must thereafter work perfectly throughout the next flight. Sometimes you have to check the plane operator, to eliminate the flight trouble! Assuredly the airport radio maintenance man must be a man of ability and tact.

The following are the more important requirements for assistant radio operator (Airways). This is a Civil Service job starting at $1800 a year with a $60 raise every year up to $2000. This sounds like a pretty good job, and it is. Assistants may be promoted to operator in charge, any time after six months' service, at salaries ranging from $2300 to $2800, and also to radio electricians at $3000 and more per year. The assistant's job is open to any operator between 18 and 40 who is sound of wind and limb and who has no impediment of speech or "brogue" accent. Applicants will not be examined personally, but will be rated on their training, experience and fitness. They must be able to send and receive and type at speeds up to 30 words per minute.

There is a popular belief among civilian radio men that ex-army and ex-navy men get preference when it comes to employment in aviation. This misconception is caused by many unrelated facts. It is a fact that the Civil Service Airways jobs are often secured by *disabled veterans*. These men are legally entitled to a handicap on their examination which often puts them at the head of the eligible list. Civilian flying concerns are honeycombed with good men who learned the air game in the army or navy. These men favor their friends because they know the air game as well as radio.

Radio operators who learn the business of commercial aviation will progress upward as airport superintendents, field managers, plane despatchers, air-line managers and officials of air companies. There are few old-time aviation radio operators, because the good ones have been promoted out of radio and more directly into aviation.

Now do you see what sort of men aviation radio operators must be? Pretty good all-around men. Men who know three sides of the game: flying, operating, and maintenance. Able to sympathize with the troubles of the other fellow but not to condone his faults. Men without alibis—men of character, not afraid. To this type of man aviation radio promises much interesting work, on the ground and in the air, as well as a great future; a future to be filled with accomplishment and personal advancement. I have trained radio men of this type in the navy for years and am now training men for commercial aviation jobs and I find it always works out so that the better the man the better the aviation radio operator will be.

British Radio Hoax

(*Continued from page* 854)

from the British Broadcasting Company studios, and a broadside in the press, opened the war. On a certain fateful day, named and dated exactly in this year of Our Lord 1931, two or more heavily armed vans (trucks) would set forth, manned by grim, determined engineers, who would stop at nothing (except the houses of pirate listeners), and one after another would bring these evil-doers to justice.

The vans were to be armed with everything of the latest in radio direction-finding apparatus, ultra-sensitive and extra-accurate. They were to cruise the streets of London and the suburbs at first, and then go on to other localities. Dark and mysterious would be their movements, they would come with a blast of trumpets, "alarms and excursions off stage". In other words, they would not sneak into a town and catch these good people unaware. They would give everyone fair warning when they were about, and it was just too bad for those who failed to take advantage of this fair play and get their licenses in the meanwhile. They would not question any license which might show a more recent date than the radio set—but Heaven help the poor soul who had none!

For a week they operated with the grim efficiency of Scotland Yard closing in on a band of criminals, while whole veins of shivers ran up and down the British radio spine. It was found, said Post-Office authorities, giving out communiqués as from a battle front, that the morning was the best time to work, when the husbands were away and the wives were whiling away their housework hours with gay melody. Not three days after the opening of the campaign, there appeared in both the London newsreel theatres—one on Charing Cross Road, the other on Shaftesbury Ave., in the West End, pictures of these wonderful automobiles at work catching pirates. We were shown the inside of the "van," filled with lovely direction-finding sets, wheels, and gadgets. We were permitted to see the engineers actually track down a set, and went with camera right to the front door of a house, where the inspector rang the bell, asking to see the license of the householder; and when the good wife admitted, with very evident embarrassment in the face of the camera, that there was no license, she was politely but firmly warned that His Majesty's Government would find themselves obliged to proceed against that family to the full force of the law. There we had the working of this new policing system displayed to us in brief, convincing form.

The vans moved on and ever on. They were announced in Richmond, in Westminster, in Mayfair, in Acton Town and Poplar—and the citizens of each of these boroughs

Radio Fever

(*Continued from page* 873)

ultra-short waves with quasi-optical characteristics, up to normal short waves of about 30 meters wavelength, has opened unusual possibilities for the physician and new hopes for the sick.

* J. Kowarschik: Electrical Short Waves and Their Importance in Medicine, Wiener Klinische Wochenschrift, Volume 30, pp. 957-962, July, 1931.

† J. Paetzold: The Temperature Increase of Electrolytes in a High-frequency Condenser Field and Its Importance for Medicine. Zeitschrift fuer Hochfrequenztechnik, Volume 36, September, 1930, p. 85.

ran shivering to the branch post offices, "queing up" in long lines to wait their turns to pass the government their ten shillings for a slip of paper guaranteeing them protection and peace from the stern vans which so inexorably sought them out. The radio detectives went to Oxford, to Cambridge, to Dundee and Glasgow, and from John o' Groat's to Land's End, heralded far and near by the ever vigilant press and the unbiquitous newsreel. And in Glasgow and in Plymouth, on the Isle of Wight and on Clydeside, the lawbreakers fled to cover themselves with licenses.

New Licenses

At the end of about two weeks, an announcement was made that some thirty to forty thousand new licenses had been taken out, and that the radio vans were really proving themselves effective. They had, in other words, made perhaps, £20,000 (nearly $100,000, at par value) for the Post Office and the B.B.C. to split between themselves; and they had installed a proper respect for the law into many hitherto unpatriotic British breasts. Whereupon for a moment they dropped from the public eye.

Can It Be Done?

Until suddenly the public began to take note of the mutterings of a few cynics who had from the first said they did not believe that any such vans could be built. How, said these cynics, could anyone detect a receiving set? Of course, they might wait until some set oscillated, and then take a "bearing" on it. They would then move along 100 yards or so and wait until the set oscillated again, and take another bearing—"Oh, yeah?" (they are using that expression over here now, thanks to the American talking films.) "That would be just fine; but by the time they had gotten to another spot, the chances were that the listener would have tuned off. Anyway, he would not still be oscillating. They might, of course, try to tempt him to oscillate by doing a bit of fancy reradiation themselves; but that would bring in perhaps twenty people in all the London area—and probably eighteen of those would have licenses anyway."

The Secret Is Out

So the secret seems to be that the vans were just used for the publicity they could obtain. At least, the British public is getting very suspicious that it has been badly hoaxed. It is true the van riders rolled merrily along the residential streets twirling their frame aerials and looking fierce, but in reality they listened carefully for any sounds of radio broadcasting that might come through open windows. It has been a fairly mild Fall in England, and the British are fresh-air fiends. They keep their windows open until the last possible moment. Even an amateur detective might be able to learn that some house was equipped with a radio set; and it would not need a remarkable pair of ears to trace it down. It is reported that the van riders went into houses, after listening at doors and windows, whenever they heard strains from a radio.

Anyway, the B.B.C. and the Post Office are rubbing their hands over a tidy sum of delinquent license fees; and the English people, who, in spite of all American belief to the contrary, are quick to see a good joke on themselves, are chuckling at their own gullibility in not even questioning how these vans could find them—the while the Post Office says it has something even bigger and better in the way of "radio van" now coming out, which will detect any metal antenna of over six inches long.

With which, one journalist opines, they will find a wonderful amount of drain-pipes, eaves-troughs, and household plumbing.

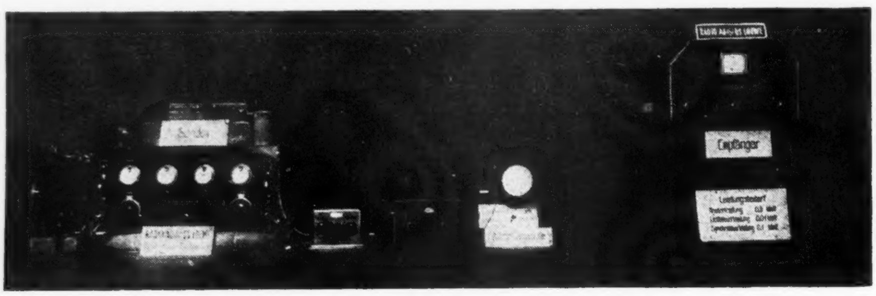
The March of Television

(*Continued from page* 853)

results? It is, simply, that television research along present lines is restricted by severe limitations.

First, there are limitations of apparatus. These are more evident at the receiver, which must be comparatively small and cheap, than at the transmitter. If the image is to be viewed directly on a Nipkow disk (as it is in several present commercial models), home-movie quality demands about 400 holes on the spiral curve spaced at least two feet apart. As such a disk would be at least 200 feet in diameter, it is apparent that the method is preposterous for practical installation. With the drum-type scanner it might be possible to reduce somewhat the dimensions, but even then the drum alone would fill a fair-sized house. Present cabinet-enclosed disks and drums give a picture only about one and one-half inches square, which is made to appear somewhat larger (but not clearer) by a magnifying glass directly in front of it. But the disadvantage of the magnifying glass is that the observers beam to spread with distance, due to the mutual repulsion of the electrons of which it consists. One cannot focus the bright spot of an ordinary cathode ray oscillograph down much narrower than an eighth of an inch or so. For a 400-line television picture with such a tube, the spot could be no wider than about one hundredth of an inch. It does no good to speed up the electronic scanning operation to the extent of a 400-line picture if the successive tracks of the spot greatly overlap; the net result is not a 400-line picture at all, but something far less clear.

It is one of the cardinal communication principles that the faster you wish to transmit intelligence (or the amount of it you wish to send in a given time), the wider must your electrical channel be. This theorem applies to telegraph, telephone and radio alike, and television is no exception. Larger pictures and more detail mean wider television channels. Wider channels, in turn, mean very special and expensive ar-



THE COMPLETE CATHODE SYSTEM

At the left is shown the complete Von Ardenne cathode ray tube transmitter for television, while at the right is the cathode ray receiver. These are being commercialized by Loewe in Germany

must be huddled together within a fairly narrow field of view.

These limitations of apparatus size may be avoided by projection methods which, however, introduce difficulties of their own. One is adequate lighting, the difficulty of which increases as the square of the picture size. In other words, projection to the size of home movies would require something like one hundred times as much light as the present small pictures. Then too, there is the matter of clearness. A 60-line picture is no clearer projected on a screen than it is on the disk. To get 400-line definition on the screen, assuming a disk about ten or fifteen feet in diameter, we are faced with the problem of placing 400 lenses, perhaps an inch in diameter, along a spiral curve around the disk, each lens center being accurately located within less than one thousandth of an inch, and each lens being accurately ground to the same optical characteristics. However difficult, this problem is perhaps not impossible, particularly in theater television where the expense may be justified. Projection methods will bear watching in the future.

The great advantage of the cathode-ray systems is that the moving parts, comprising only an electron beam, have no inertia in the ordinary sense. But these systems have disadvantages of their own. The beam must be projected through a vacuum, which entails a glass bulb about three times as long as the screen is wide. For a cathode ray screen of home-movie size it is difficult to see how the tube itself could be less than six feet long. Most people would not want a vacuum tube filling half a room, even if they could afford to buy a replacement every year or so.

Perhaps the most serious limitation of the cathode-ray system is the tendency of the rangements on wire lines; or in the case of radio, wide sidebands with consequent blanketing of other stations which might like to transmit also.

It is now standard television practice to provide twenty pictures per second. A 60-line picture has 3600 elements, corresponding to picture currents of frequencies up to 1800 cycles per picture. Thus the highest picture frequencies in 60-line scanning are around 36,000 cycles per second or 36 kc. Should the definition be improved enough to produce a 120-line picture, the highest picture frequencies would run around 144 kc. And should the definition be carried up to the home-movie standard of 400 lines, the picture frequencies would approach 1600 kc!

The upper frequency limits of open wire-lines are, of course, not definitely fixed, but in general they are around 30 to 40 kc. In populous areas underground cables would be necessary and these, by special loading, could also be arranged to transmit frequencies up to perhaps 40 kc. Present 60-line television, therefore, is well within wire possibilities for countrywide service, and the same is true of the 72-line scanning used in the Bell Laboratories two-way system, except that the latter might require two special lines instead of one, separating the picture frequencies into appropriate bands by means of filters. But 120-line scanning would require about four special lines, while 400-line scanning corresponding to home-movie quality would call for something like fifty wire channels. Inasmuch as each of these fifty channels must be much more carefully balanced than for audible broadcasting wire lines of today, to say nothing of the difficulty of filtering out fifty bands of frequencies and recombining them, it is evident that nation-wide diffusion of high-quality television, comparable to present

chain distribution of audible programs, is far in the future if possible at all.

The radio probabilities are likewise limited. The 36-kc. picture frequencies of 60-line scanning call for two 36-kc. sidebands, one on each side of the carrier, or a complete radio channel 72 kc. wide. This is within the limits of present television bands in the neighborhood of 2000 kc. and 3000 kc. Should definition be increased to 120-line scanning, however, the channel width would be about 288 kc. This channel would require some rearrangements, but it would be entirely possible. Home-movie definition, however, would inordinately increase the channel width to over 3000 kc. If one of the present television transmitters attempted such broad modulation it would blanket all three present television bands and the ship, air and amateur bands between them, to say nothing of our entire present broadcast band! Even if such a station were permitted on the air it would not assure dependable television service to any great distance, because much of the time radio fading effects would mar the image before they got more than 25 to 100 miles from the transmitter. In addition, there is the difficulty of designing a receiver to cover such an enormous frequency band.

It is possible, by using ultra-short radio waves, to avoid both channel restrictions and nearby fading difficulties at one bound. With a carrier of 40,000 kc., 3000 kc. modulation does not bulk so large. Broadcasting on about 7 meters has been tested in Berlin during the past two years, and in New York City the RCA-Victor Company is said to be sending out experimental ultra-short wave television. Those waves gave excellent coverage in the comparatively open city of Berlin; but among the steel towers of New York results may be quite different. Ultra short-wave transmission, like everything else in engineering, demands a price for its boon. The waves are propagated practically like light waves with no reflections from the ionized layer, so that the range scarcely exceeds that of a visible beacon, being mainly dependent on the height of the transmitter above the ground.

Present Progress

These limitations show why television development has moved slowly in the past and continues to move slowly in the present. Rapid progress, it would seem, can only be initiated by the discovery of some entirely new principle. It would be far from the truth, however, to regard the art as static or to consider present efforts futile. An understanding of these limitations leads to better appreciation of results obtained in spite of them. A great deal of splendid research is steadily going forward.

The RCA-Victor Company and the Philco Company are said to be working on home televisors of the cathode-ray tube. Little information about them is available except that they may be ready within a "short time" and will give "excellent definition." It is difficult to see how this definition can approach the 400-line home-movie picture. Perhaps a more likely figure is something like 120 lines—a mere personal guess, of course, based on the limitations detailed above.

Everyone who converses over the Bell Laboratories two-way television system is delighted with it. You forget all about wires and whirling disks, so perfect is the illusion of an actual meeting in which you are participating. Burdened only with the task of transmitting clearly a single face, this 72-line system stands out in present relative perfection above others viewed. There is no reason why it could not soon be installed in the larger cities for regular service.

Another immediate possibility is theater television, which has received some atten-

tion from engineers of the General Electric Company and also from Sanabria. In the theater is placed for bulky and expensive apparatus that could never be installed in the home. The expense of elaborate equipment and multiple channels also, is better proportioned to the theater. Here, in the writer's opinion, may be the real beginnings of television as pure entertainment.

With present 60-line equipment the foundations of television artistry and showmanship are now being laid. High up in the New York headquarters of the Columbia Broadcasting System is a new television studio, where, daily, well-known artists perform in the flickering light of the flying spot. On Fifth Avenue the Jenkins Company, also, sends out regular programs, well presented and entertaining. Other stations in the city and elsewhere are in daily operation. Creditable receivers, such as the Jenkins and the Baird, are on the market.

Outstanding among the smaller research organizations is the Jenkins plant at Passaic, New Jersey. Here a television camera has been developed which can be pointed and focussed with the ease of a standard movie camera on any well-lighted object, near or distant, inside or outside. The operator, looking into a combined view-finder and monitor on the camera, sees the picture resynthesized by the same disk that has analyzed it, in light from a neon tube connected to the amplifier output. This camera opens to television the whole field of artistic lighting as developed in the theater and the movies. Another Jenkins development is a projection receiver giving a picture a foot square. This, in the present magnifying-glass era, should arouse enthusiasm, particularly if the definition can be advanced beyond the 60-line picture. And in larger form, it has distinct possibilities for the theater.

Thus the slow march of television is a forward march showing definite gains against severe limitations. One of these days someone may evolve an entirely new principle before which the limitations will fade away. It is said that a short time before the Wright Brothers flew at Kitty Hawk, learned men in Europe proved conclusively by mathematics that human flight was impossible. Perhaps something similar will

PROJECTION TELEVISOR
In this new Jenkins receiver which employs the lens scanning disc, the received pictures are projected on a ground glass section which enables everyone in the room to view the living objects

happen in television. But until the thing is done we might remember the phrase, "figures do not lie."

Quartz-Crystal Receiver

(*Continued from page* 838)

of which is considerably favored by the audio correction circuit. The result is, on a quiet night less background will be heard on the ordinary super while the reverse is true on a noisy night. (The tube hiss, however, is quite negligible. Reference is made to it only as an interesting point, and in an effort to provide an impartial picture of what the Stenode is and what it will do.)

The fundamental circuit is shown in Figure 6. No values are given, nor is the super switch indicated. These details are reserved for the constructional article to follow.

The switch is mounted on the shaft of the balancing condenser, so that when the balance control is turned all the way counterclockwise, the following changes are made: The primary of the correction transformer is opened, the first audio stage being changed to a resistance—coupled stage with an impedance leak (the secondary of the correction transformer). The crystal is thus shorted out. The center tap to the bridging condensers is opened, and the lower side of the first i.f. secondary is grounded making available the entire winding, thus increasing the gain.

It will be observed that the circuit is fundamentally that of a superheterodyne, the input i.f. stage being tuned with the quartz crystal. The radio-frequency amplifier is preceded by a band-pass pre-selector and immediately followed by the first detector. A simple oscillator, with a specially-designed tracking condenser, is employed in preference to the usual padding arrangement. The output of the tuner, whether operated as an ordinary superheterodyne or as a Stenode, has a straight-line audio characteristic and may be input to any high grade power

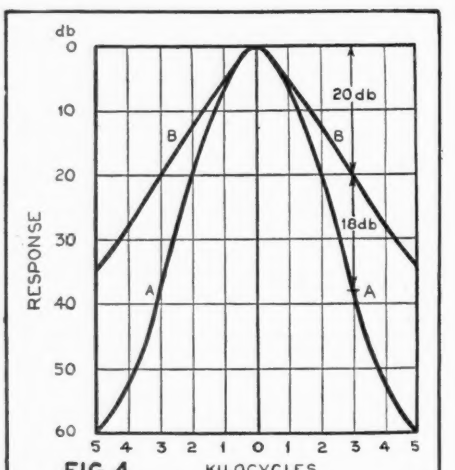


Figure 4. Curves showing the rejection and audio-frequency attenuation characteristics of the receiver

amplifier, such as the Loftin-White or the special amplifier to be described later in these articles.

The dial is provided with two ratios—the low ratio, (5 to 1) being employed for

rough tuning and when used as an ordinary superheterodyne. For final Stenode tuning, a small clutch is actuated, under the main knob, changing the ratio to 250 to 1. The selectivity of the receiver is such as to make essential this very delicate control. Tuning is also accomplished visually, rather than by ear, as a 10th of a dial division will make all the difference between satisfactory and poor reception. It must not be thought, however, that the receiver is difficult to tune. The high-ratio dial greatly facilitates adjustment, and the knack of accurate tuning is quickly acquired.

It is, of course, possible to convert any superheterodyne into a Stenode, but a degree of engineering skill and the following special parts will be required: 1 crystal tube, 1 two-ratio dial, 1 input i.f. transformer, 1 correction transformer and 1 balancing condenser. The special parts for the complete tuner include, in addition to the above, 1 chassis, 1 set of Stencoils, 1 output i.f. transformer and 1 tuning condenser gang.

Complete constructional details, parts lists and further diagrams will be given in the second article in the next issue of RADIO NEWS.

Condenser "Mike"

(*Continued from page* 849)

The stretching process is a delicate operation, but can be accomplished in this manner. Put a very thin film of non-medicated vaseline on the rim of the back case, A. This is to prevent tearing of the diaphragm. A further precaution is to remove all microscopic burrs from the mouth of the back case with very fine sandpaper. Connect a pair of phones and a 22½-volt B battery in series with the two terminals of the head and screw the back case into place. As the diaphragm comes close to the back plate, H, clicks and scraping sounds will be heard in the phones. Continue to advance the back case until there is no contact between the diaphragm and this back plate. Now blow on the diaphragm. At first the diaphragm will bellow in under the gentle air pressure and clicks will be heard. Slowly advance the back case until ordinary blowing on the diaphragm does not produce a click in the phones. The locking ring should then be brought into place and the diaphragm again tested by blowing for tension.

Attaching the Head

The head is now ready to attach to an amplifier. However, if an amplifier is lacking, the instrument may be tested in this manner. Every experimenter has a single-circuit regenerative short-wave receiver with one or two stages of audio amplification. Short out the small antenna-coupling condenser, if there is one, and place the completed head in series with the antenna. Place the phones in their usual place in the circuit. Find a vacant space somewhere between the 40 and 80-meter bands and bring the set into oscillation. A little adjustment with the receiver and soon the room noises will begin to come in with astonishing clarity. The ordinary voice of a person anywhere in the room will be clearly distinguishable. With the short-wave receiver as amplifier and long leads to the phones in another room the head may be thoroughly tested for voice and music.

Such improvements in this unit as desiccating at a low heat and thoroughly sealing against moisture and dust may be incorporated, which operation is left to the ingenuity and discretion of the builder. Long and satisfactory service may be expected from this head. Several of these units have already been in use some months.

Phenomena Underlying Radio

(*Continued from page 847*)

without, in the slightest, affecting the vacuum of the tube, for these particles can pass as readily through solid matter as a comet can pass among the planets of our solar system. It also explains why sodium of potassium can be passed, by electrolysis, through the solid glass of an ordinary electric-light bulb for the preparation of a photoelectric cell.

Let us take for example a metal conductor, a piece of copper wire. The atoms are spaced with the same relative openness as we have just considered. The electrons of the atoms revolve around the nucleii, and the atoms themselves are moving and turning in every imaginable manner, due to thermal agitation, and in their state of continually rushing about they are colliding with one another. In a collision of one atom with another an interchange of energy may take place, one atom may lose momentum, the other gain it. There may be an interchange of electrons, electrons may be knocked free of the atoms or caused to change their orbits, or energy may enter the body in the form of photons. The possibilities are innumerable.

What is the importance of considering these general cases, we may ask. The importance is that if we have a reasonably clear picture of what theory says is taking place, we will be able to apply simple reasoning to the various phenomena, such as piezo-crystal action used for constant-frequency oscillators; magneto-strictive effects used in loudspeakers, in oscillators, and in measuring instruments; photoelectric phenomena, so important in television and in talking pictures; why a vacuum tube without a heated filament *is* possible; why photoelectric cells are more sensitive to light of one color than to another; how polarized light can be controlled by electric fields and other phenomena being used in both radio and television.

Returning now to our piece of wire—a great number of atomic and electronic interchanges of energy are taking place resulting in the liberation of free electrons. These electrons, in the case of copper, do not get very far before they attach themselves to other atoms with never a relatively great number of electrons free at any instant, due to the magnitude of the forces within and between the atoms of copper. When a potential is applied to the wire the electrons will tend to drift in one direction, constituting the current through the wire. There are, as we will see later, some elements in which the production of free electrons at ordinary temperatures is sufficient to be useful. Now suppose we heat one end and make provision to keep the other end cool. The agitation of the atoms will be increased in the heated portion, thus increasing the number of free electrons, which means a difference of potential between the two ends of the wire, the hot end becoming negatively charged (for iron, this effect is reversed). Here we have the heat, the kinetic energy of rapidly moving atoms, being transformed into an electric potential. This is known as the Thomson effect.

There are many other interactions of heat and electricity which we will consider in more detail later, some of which are worth studying with an eye to useful application, for there is always the possibility of applying a well-known effect in a novel way. We have a beautiful example of just such in the apparatus very recently developed by Dr. Van de Graaf at the Massachusetts Institute of Technology for the production of a potential of 1,500,000 volts, in which he made use of the friction of an insulating material against two rapidly moving belts of silk, each belt charging a large metal sphere, between which the potential was developed. The production of electricity by friction has been known for centuries, but never has been so cleverly applied. Many have attempted to produce these high voltages, but no one has used such a simple apparatus. The Van de Graaf apparatus costs about $90, while more complicated machines, such as generators and transformers, cost many thousands and are much less reliable in action. We may add that Dr. Van de Graaf is building a much larger apparatus with which he expects to develop as high as 15,000,000 volts. There is serious talk of considering a modification of the apparatus for the commercial production of small current, since as an electrical machine it is very efficient. At the moment this may seem remote in interest from radio, but it is not impossible that such a machine might be used to good advantage for supplying small, steady currents for tubes.

Again returning to the copper wire: any mechanical disturbance of the piece of copper will effect the motion of the atoms and the distribution of the forces within and between the atom, thereby affecting the balance of free electrons and the rate at which collision and interchange take place. Compression, tension, twisting, bending, any external force has to be met by a rearrangement of internal forces and such a rearrangement changes *all* the so-called properties of the copper electrical, magnetic, thermal, optical (in the strict sense of the word the piece of copper isn't the same). In fact, we are justified in making a generality: if any change is made in one of the physical or chemical properties of a substance, inevitably changes occur in all the others. On first consideration such a sweeping statement may seem entirely unwarranted, for the question may be asked, "Do you mean to say that if light falls on a piece of copper its electrical actions are changed, or the reverse? Does this mean that sound waves impinging on the copper would change its resistances or that a magnetic field would result in optical changes?" Yes, it means just that, but we must hasten to add that some of these changes may be beyond our present instruments to detect, or rather that, with some substances, some of the changes may be so minute as to be immeasurable at the present time. Copper exposed to light does not produce great numbers of free electrons which have the velocity to escape from the attraction of the copper wire, but potassium, another element, does give off measurable quantities of these photoelectric electrons and caesium, still another element, reacts even better and is, for this reason, used in some photoelectric tubes in preference to other substances. In this case it is a question of the quantity, not the quality, of the action; likewise with iron and magnetic changes. The forces within iron allow the greatest changes to be evident, but magnetic action takes place in all other substances.

Probably at this point we had better answer a question which has no doubt come to mind. What is meant when it is said that all the variables but one are held constant in an experiment or a measurement, as in the case of holding the plate voltage and filament current of a tube constant while the grid voltage is varied in order to see how the plate current varies? Or is this possible? Theoretically it is not possible, but so far as the accuracy of our measurement is concerned the very minute

variation in the other factors caused by the change in the grid voltage is insignificant. And so with any set of forces, one or two of the group may be going through *very rapid* changes of magnitude, but the others are but slowly and minutely varying. This is not as theoretical or outside the realm of practice as we may imagine, particularly in the field of vacuum tubes and the electronic arts, where we are dealing with only a relatively few electrons at a time.

For example: recently a vacuum tube has been developed by B. J. Thompson, of the General Electric Company, which is capable of measuring .000,000,000,000,000,01 amperes. This means that as few as sixty-three electrons per second can be detected. With such detection as this made possible, we may expect to see more of the interactions of matter and energy put to work.

It is interesting to read that Thompson in designing this tube was forced to consider the following phenomena as sources of current within the tube:

1. Electrons from the filament.
2. Positive ions (which are atoms with a deficiency of electrons formed by collision between the electrons constituting the plate current and the gas molecules in the space).
3. Electrons emitted due to the temperature of the grid.
4. Leakage (drift of electrons through the glass).
5. Positive ions emitted by the filament.
6. Electrons emitted from the grid under the influence of light (photoelectric electrons).
7. Electrons emitted from the grid under the influence of the soft X-rays (X-rays of long-wave length) given off by the plate due to its bombardment by the plate current.

In the above list we see the importance of atomic, electronic and photon (light and X-ray) interaction, and how, when our attention is directed to greater and greater accuracy, we must take account of more and more factors.

It is very natural for us to be so familiar with a phenomena, having in our mind the most astounding actions involved, that we do not stop to think of the multitude of lesser effects. We have seen this in the above example, for one does not usually think of a vacuum as a producer of X-rays. Another example, under our nose, is the modern pentode tube. Years ago, if a vacuum tube "blued" it meant that there was gas present which was being ionized sufficiently to be luminous (similar to a modern neon tube). When a good pentode "blues" it is *not* due to the ionization of gas but to the fluorescing of the glass due to bombardment by electrons which have missed the plate.

We have covered a lot of ground in attempting to point out that electrons, protons and photons are the mechanisms with which the physicist has been able to explain the various forms of energy and their interactions. Our review may seem to lack precision because we have not expressed the relations between the various factors in mathematical form, introduced equations and formulas. As we proceed, in following articles, to consider in more detail the phenomena which we have been enumerated above, we will be able to get down to definite quantitative relationships in some cases, but even then it is hoped, by a non-mathematical approach, we will be able to form our picture of what is taking place.

Radical Circuit Design

(*Continued from page* 843)

volume control. True automatic volume control has three disadvantages. The first is that receiver sensitivity rises automatically to a maximum between signals, so that as the set is tuned between signals it sounds terribly noisy. This, however, is only an objection to the lay public. The second disadvantage is that if it holds volume on a fading signal constant, the noise level must fade up and down behind the signal if it is at all week, since a fading signal will almost invariably fade through a range of from quite close to—or below—the noise level to well above it. Such a condition does not make for enjoyable reception, as the third drawback likewise does not. Signal fading is usually caused by ground and sky waves arriving at the receiver progressively "in" and "out" of phase, and this often results in serious side-band or modulation distortion as well as varying volume. Automatic volume control can only hold volume constant, or nearly so, at best, and cannot correct this varying distortion.

Nevertheless, it has been felt best to include it in the receiver described herewith, since much of the extreme distance reception of short-wave sets is indulged in for thrill rather than entertainment, and if automatic volume control can in any measure facilitate logging the call of a station many thousands of miles away, even though it may not be able to make for an enjoyable program, it is of enough benefit to justify its inclusion.

The receiver embodying the development described above is illustrated in Figures 2, 3 and 4, with its circuit diagram in Figure 5, and its operating curves in Figures 6, 7 and 8. It is a ten-tube all a.c. superheterodyne having but one tuning dial to tune from 16.5 to 550 meters, or 18,000 to 550 kc. Basically the circuit consists of a tuned –24 screen-grid first detector, tank-tuned –27 oscillator, –27 harmonic generator tube, two stages of 465 kc. dual-tuned, or siamese, –51 vario-mu i.f. amplification, –27 automatic volume control tube, –27 second linear-power audio detector, push-pull –47 pentode out-put stage and an –80 rectifier.

Starting at the left of the circuit diagram, Figure 5, there is the double-bladed switch which serves to connect the –24 first detector grid either to the secondary of the broadcast-band antenna transformer, to which is permanently connected the proper section of the gang-tuning condenser, or to successively connect it to one of the four short-wave antenna coils, and in each case to pick up the short-wave tuning condenser, a 200 mmfd. midget type, which is the auxiliary, or trimmer, tuning adjustment for the short waves. The upper switch serves only to disconnect the antenna from the broadcast band primary and to reconnect it to the first detector grid through a permanently adjusted antenna-compensating condenser for short-wave operation.

For broadcast band reception the –27 oscillator is directly coupled to the –24 first detector by a small coupling coil in the first-detector cathode lead, while for short waves the oscillator is coupled to the proper short-wave coils by small coupling coils, all in series, in the –27 harmonic generator's plate circuit. The lower portion of the switch, therefore, serves only to include this oscillator-coupling coil in the first-detector cathode lead for broadcast-band reception, or to cut it out of circuit for short-wave reception. Actually, the upper and lower sections of the switch in Figure 5 are really only s.p.d.t. switches in action, but are physically five-point switches in order that they, being ganged to the main band selector switch, may maintain one set of connections throughout four successive positions of the coil selector switch.

In examining the first detector circuit, two

by-pass condensers will be noticed shunting the bias-resistor, R1, one a 1/10 mfd. paper condenser and the second a smaller mica condenser. The reason for this is that the larger value is desirable on the broadcast band, but its impedance rises too high on the very short waves, so it is additionally shunted with a capacity satisfactory for these.

The automatic volume control tube is seen in the diagram just below the two i.f. tubes. It functions as a rectifier actuated by the i.f. carrier voltage. This it rectifies and applies to the i.f. control grids, this operation serving to maintain a balance between the signal voltage appearing at the second, or audio, detector grid and varying signal inputs. Its grid is coupled to the plate of the second i.f. tube through a condenser and r.f. choke, while all audio modulation originally appearing on the signal carrier is filtered out by an audio filter consisting of a resistor in its plate lead and a by-pass condenser. This system of automatic volume control will hold all signals from about 20 microvolts on up to constant output, and it is in no sense a "blast eliminator" such as is usually found masquerading as automatic volume control in most commercial sets.

It is impossible to tune accurately to the peak of a carrier by ear, since in tuning it will cause response to appear rectangular in terms of dial readings against volume. For this reason a tuning meter is included in the circuit. This meter is in the cathode lead of the i.f. tubes, and besides serving to provide an initial C bias, reads their plate current, plus carrier voltages, as the set is tuned. Thus by means of observing carrier deflections on this meter, the set can be accurately tuned to a signal without the distortion that might result if it were tuned only by ear.

Because the sensitivity of the set, but not its volume, is controlled entirely by signal strength, it will jump to maximum sensitivity between signals, and in consequence of the very high sensitivity, show a quite high noise level on no signal. As soon as a signal is received, this noise drops out.

The second detector circuit uses a Clough audio coupling system to the -47 push-pull pentodes. Their circuit is normal except for the resistance and condenser shunted across their plates to cut the high response a little more sharply and minimize hiss. Tone control is provided by a rheostat and condenser shunting the audio transformer primary.

The power supply uses an -80 rectifier, an over-size power transformer and a two-section filter with dry electrolytic condensers.

Examining Figure 3, the chassis is seen with the top of the large shield housing the gang condenser and all coils but the oscillator removed. The four short-wave coils are clearly visible, as is the gang condenser, 600 kc. oscillator trimmer-screw adjustment, and the broadcast antenna coil, with its small primary visible in its center. The tuning meter is seen above the dial, and the i.f. transformers in the three round aluminum cans, their trimmers accessible from below. The power transformer is to the left of the dial, and the audio transformer at the left rear.

Looking at the bottom of Figure 4, the placement of parts is reasonably self-explanatory, the wave change switch is seen next to the short-wave antenna-tuning condenser, and behind it is the shielded oscillator coil. The antenna-compensating (series) condenser is seen at the left (rear) corner of the chassis, near the antenna and ground binding posts. The control arrangement seen from the front is, left to right, "on-off" switch and volume control, tone control, tuning, short-wave antenna tuning and five-point range-selector switch.

The dial is divided into five differently colored sections, corresponding from left to right, to the five successive positions of the range-selector switch. The four left or short-wave sections are calibrated directly in megacycles, and the right section in kilocycles from 550 to 1500 kc., less the final zero, or from 55 to 150.

In Figures 6, 7 and 8 appear performance curves on the set. From Figure 6 the sensitivity is seen to vary from 1.8 to 2.8 microvolts, which is fully adequate for any American location. Figure 7 shows a band width of 28 kc., 10,000 times down, which simply means 10 kc. selectivity.

Figure 8 is quite interesting, indicating the power output in watts plotted logarithmically (as it sounds to the ear) against microvolts input. It will be seen that the power output reaches practically a maximum at 20 microvolts absolute input and remains constant (at whatever the volume setting may be) from there up. The fidelity curve is flat.

As for results—since an afternoon and evening of playing with the set in Chicago will bring in at least one broadcast station for every dial degree, police stations all over the country, plane-to-ground conversations, television signals, amateur phones from all over and all of the principal American, European and Asiatic short-wave broadcasters, all without any fading—what more can be asked?

New Tubes

(*Continued from page* 858)

does not seem to be objectionable. For r.f. power amplifiers, this hook-up has come to be used frequently.

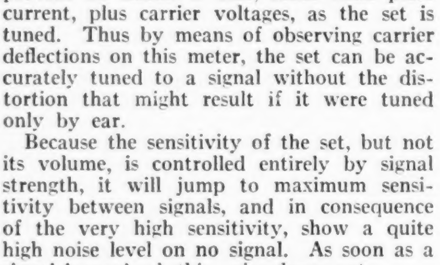


Figure 11. Percentage harmonic distortion plotted against modulation percentage for four different carrier input voltages

In Figure 4B we show a schematic circuit of a single-stage radio-frequency power amplifier. The grids are given such a high bias that only very little plate current flows. Only the positive part of the signal voltage produces power output in the tube. Therefore, the tubes alternate in delivering one-

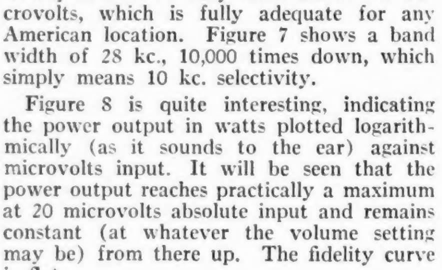


Figure 12. Showing the flat frequency characteristic of the Triple-Twin. These curves were made with a resistance-coupled input and a resistive load

half cycle to the load.

Under these conditions the maximum plate voltage is 450 volts and the maximum d.c. plate current 50 ma. when the carrier is

modulated. The plate dissipation is then 15 watts and the maximum allowable r.f. grid current 5 amperes.

Examples of typical operation: With a plate voltage of 350 volts and a grid bias of approximately — 5 volts, the d.c. plate current would be 43 ma. (unmodulated). With a modulation factor of 1, the carrier output is 3 watts. With a plate voltage of 450 volts, a grid bias of — 8 volts and a plate current of 36 ma. the carrier output was 4 watts.

Class C Service

When the grid bias is increased still more, a higher efficiency can be obtained but with a greater amount of harmonic distortion. Sometimes this is an advantage; for instance, in the case of frequency doublers. If the tube is used in a transmitter-output stage, these harmonics must be filtered out. When a large enough signal voltage is put upon the grids, this circuit permits a very large output to be obtained.

When the 841 is used in a Class C amplifier, the maximum plate voltage is 350 volts for modulated carriers, 450 volts for c.w. and 450 volts r.m.s. for a.c. on the plate. The maximum d.c. plate current is 60 ma., the maximum plate dissipation 15 watts; maximum d.c. grid current is 20 ma. and maximum r.f. grid current 5 amperes.

Typical examples: With a plate voltage of 250 volts and a grid voltage of — 20 volts the power output was 6 watts. With a plate voltage of 350 volts and a grid bias of — 25 volts, the power output was 10 watts. A power output of 13 watts can be obtained with a plate voltage of 450 volts and a grid bias of — 30 volts. The grid leak should be about 5000 ohms.

TABLE 1

	RAYTHEON ER-239		RCA 239		
HEATER VOLTAGE	6.3	6.3			6.3
HEATER CURRENT	.3	.3			.3 AMP.
PLATE VOLTAGE	90	180 (MAX.)	90	135	180
SCREEN-GRID VOLTAGE (MAX.)	90	90	90	90	90
CONTROL-GRID VOLTAGE (VARIABLE)	-3 (MIN.)	-3 (MIN.)	-3	-3	-3 (MIN.)
PLATE CURRENT	4.4	4.5	4.4	4.4	4.5 MA.
SCREEN-GRID CURRENT	1.3	1.2	1.3	1.2	1.2 MA.
PLATE RESISTANCE OHMS	300,000	750,000	375,000	540,000	750,000
AMPLIFICATION FACTOR	300	790	360	530	750
TRANSCONDUCTANCE (Ecg,-3V.)	1000	1050	960	980	1000 MMHOS
" (Ecg,-30V.)	10	10	10	10	10 MMHOS
" (Ecg,-40V.)	-	-	VERY SMALL BUT NOT ZERO		
EFF. CONTROL-GRID-PLATE CAPACITANCE	.007 MMFD.		.007 MMFD.		
INPUT CAPACITANCE	.04 MMFD.		4 MMFD.		
OUTPUT CAPACITANCE	.10 MMFD.		10 MMFD.		
STANDARD FIVE PRONG BASE					

TABLE 2
TYPE 841

FILAMENT VOLTAGE (A.C. OR D.C.)	7.5	
FILAMENT CURRENT, AMPS.	1.25	
MAXIMUM OPERATING PLATE VOLTAGE	425	
MAX. PLATE DISSIPATION, WATTS	12	
TYPICAL OPERATION		
PLATE SUPPLY VOLTAGE	425	1000
GRID VOLTAGE	-5.8	-9.2
LOAD RESISTANCE, OHMS	250,000	250,000
AMPLIFICATION FACTOR	30	30
PLATE RESISTANCE OHMS	63,000	40,000
MUTUAL CONDUCTANCE, MICROMHOS	450	750
PLATE CURRENT, MILLIAMPERES	.7	2.2
PEAK GRID SWING, VOLTS.	5.8	9.2
OUTPUT VOLTAGE (5% 2nd. HARMONIC)	126	225

The Triple-Twin Tube

To our article last month on the Triple-Twin tube (295) we can add the following information:

When the Triple-Twin is used as an amplifier, the maximum plate voltage of the input section is 250 volts, the grid bias — 14 volts; plate current, 4 ma.; amplification factor, 14.4; plate impedance, 12,000 ohms; mutual conductance, 1200. The input capacity is 3.5 mmfd. and the load impedance 12,500 ohms; this is the resistance in the cathode lead. The output section has a maximum plate voltage of 250 volts; grid bias — 3 volts with a plate current of 52 ma. Under these conditions the amplification factor of the output section is 13; the plate resistance is 3000 ohms and the recommended load impedance 4000 ohms. The mutual conductance is then 4350 micro-mhos and the power output 4.5 watts.

When the 295 is used as a detector-amplifier, the grid bias has to be increased to — 14 volts with a plate voltage of 250, and it can be — 12 volts with a plate voltage of 180 volts. The plate current then drops to 2 ma. and to 1 ma. respectively. The output characteristics remain the same as above.

The 295 has a standard five-prong base. Its connections are shown in Figure 7. This is the arrangement, when looking at the prongs from the bottom.

In Figures 8-12 are shown some of the curves made with the tube connected in the circuits shown last month.

The latest data, received by us, gave the following additional information concerning the constants of these circuits:

The choke, parallel to the load, is 15 henries. The bias resistor (R4 in last month's diagram) is 270 ohms (in the amplifier circuit) and 310 ohms (in the detector-amplifier circuit). The condenser C2, across the bias resistor, is 25 microfarads; it may be an electrolytic type. A much smaller size could be used without a serious loss of the low notes.

It has been found that the detector-amplifier circuit as given in last month's article has a reversed feedback effect and therefore it is recommended that the amplifier circuit (Figure 1, last month's article) is used for detection also, by increasing the grid bias. In that case, the r.f. component must be filtered out of the output section by connecting the customary by-pass condenser between the plate of the input section and the cathode.

If the lower side of the input transformer is connected to ground, this connection must be broken and a small condenser of from .0005-.01 mfd. inserted. If this were not done, the load would be shorted. In Figure 7 we show an input circuit suitable for this purpose.

Behind That Microphone

(Continued from page 829)

the operator an unobstructed view of the apparatus, while an oscillograph gives a moving picture of the transmitter's output.

Every possible safeguard is present to insure continuous operation of the large water-cooled tubes. Tube failure may often endanger surrounding apparatus. For one thing, the supply of cooling water must be adequately sustained. Furthermore, operational steps must be taken in the proper order—as, for example, the application of filament power only when an adequate flow of water is assured and the application of plate power, after that of grid-bias voltage. An interlocking relay system functions in the event of failure, or overloading, of any unit, thus disconnecting service before any serious damage can result.

Tube replacement is handled by a push-button arrangement on the desk of the transmitter engineer. Duplicate units and rapid replacement facilities are also provided for other apparatus.

Lightning has long been a great danger to a transmitting station—and still is—although radio engineers have recently developed certain safeguards. Charges of lightning which have entered the station on the lead-in have been known to melt 30-inch condenser plates to molten liquid. Today the modern set-up includes static drains which consist of a coil and a resistor, across the apparatus from antenna to ground.

But what happens when an SOS signal is on the air?

Every broadcast transmitter is equipped with a special receiving set, adjusted for the reception of 600-meter waves, the wavelength assigned by international agreement, for SOS signals. A big loudspeaker is placed at an advantageous point so that the transmitter crew can hear any signals that come through. The operators, who work in eight-hour shifts, are constantly alert to any signals received. If any signal even remotely suggesting an SOS is heard, the station immediately telephones the nearest U. S. Navy Yard for advice. If the station operators are confident of the signal they immediately discontinue broadcasting, otherwise they await orders from the Navy Yard. Broadcasting is resumed when the Navy department sends out permission to resume by 600-meter signals.

The ordinary distribution problem involved in a network broadcast is difficult enough but in point of complexity the Nemo broadcast, often requiring seven or eight announcers, a corps of engineers and the supplementary use of short waves, takes the grand prize. Engineers and announcers have often spent days of preparation and rehearsal in advance of such an occasion.

Before describing some of the interesting engineering hook-ups used on important news broadcasts, it is necessary to speak of the piece of apparatus, recently designed, that serves as the nerve center coordinating all activities in the field.

Technically known as the "semi-portable Nemo switching equipment," the extremely flexible, compact and efficient apparatus developed and built by the engineers is a miniature broadcasting studio.

This apparatus, supplied with batteries for use where regular power supply is unavailable, is contained in a box measuring approximately 2½ x 4 x 7 feet and weighing a half ton. The "box" may be shipped to any desired centralized point from which wires are radiated to whatever locations participate in the broadcast.

When completely installed, the equipment is capable of provided ten-way communication, among as many locations. Ten announcers, within any radius—even scattered throughout the country—could talk among themselves and also to the broadcast listeners. This intercommunication is accomplished by means of special "feedback" amplifiers which permit each point to hear every other point. Inter-communicating telephone circuits are also provided. Each of these ten broadcast circuits may be controlled for volume, or switched "on the air," separately or simultaneously.

The program director at the central control point can talk to any of the distant announcers by means of the feedback amplifiers and, unknown to the listening radio audience, can direct the entire broadcast.

Provision is made for testing a set of circuits while the others are being used, for broadcast and testing equipment is provided for the rigorous checking of telephone circuits required in the broadcast field.

It is probable that only a small fraction of the millions of listeners have the slightest knowledge of the men sweating behind the scenes, in radio. They listen to a broadcast as a simple, matter of fact and connected narrative, without realizing that many men have worked for days—or, at the very least, for hours—to make it possible. That is as it should be.

But it is these "unknown" workers, unseen, unheard and unsung, who have produced a radio-minded nation which today accepts with utter calmness the voice of Col. Lindbergh speaking from Tokio, music from Chicago or an address from Rome.

A Boon to the Deaf

(Continued from page 845)

A Pointer on Demonstrating

Now for a few words concerning the problems and reactions of deaf persons. The serviceman will oftentimes find in demonstrating the Ear Aid that the deaf person trying it offers some objections to the background noise. The Ear Aid itself is silent in operation, there being no noticeable tube noise or "carbon hiss" in the microphone. The noise, occasionally complained about by deaf people using this unit (or any other highly sensitive hearing aid) is nothing more than the noise which a person of normal hearing hears all the time but to which he has become so accustomed that it is no longer noticed. The deaf person, on the other hand, does not hear these ordinary noises so that, except in unusually noisy locations, the world is a thing of quiet to him although myriad sounds of varying intensity are always present. But give such a person a sensitive hearing device and he starts to hear all of these sounds and immediately assumes that the unfamiliar noise is in the hearing device itself.

Experience indicates that this objection becomes less and less as the subject continues to use the device. After a few days he or she is no more conscious of these sounds than is a person of normal hearing.

This condition is one which both the serviceman who is demonstrating the hearing aid and the person to whom a demonstration

is made should understand. To test the accuracy of the statements made above it is a simple matter to arrange to try out the Ear Aid in a quiet location, such as in the home, for instance. Here, where there is little, if any, background noise present, the Ear Aid will be found absolutely quiet until someone speaks, and then it will reproduce the voice with many times the intensity of the sound waves which strike the microphone.

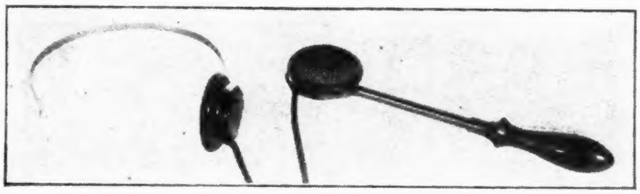
The Ear Aid for Group Use

Among the other inquiries received from readers have been a considerable number concerning methods and connections for using the RADIO NEWS Ear Aid as a group hearing device so that it may be used in church or in a meeting hall to enable several deaf persons to hear at the same time. Tests have accordingly been made to determine just how effective this arrangement is, and also to determine the type of headphones and the connections which will give the best results with it.

To facilitate these tests, and also for use in conjunction with the design and tests of the group equipment to be described next month, a connection panel was designed to accommodate up to six headphones, with individual volume controls. Switches were also provided and so arranged that the 'phones could be connected either in series or parallel, or in any series-parallel combination.

Now as to the results of which the Ear Aid is capable when used as a group hearing aid. There would be relatively little point in describing results in terms of decibels or similar units because of the difficulty in translating these terms into easily understandable values of sound intensity. In order to provide a more practical measure a simple set-up was made, using a radio receiver tuned to a broadcast speech as the source of sound. A person who had suffered a 60% hearing loss (as indicated by tests with the Western Electric Audiometer) was used as the subject of the tests. This subject first stood with his ear eight inches from the loudspeaker and the receiver volume was reduced to a point where the speech was just barely understandable to him. Then, leaving the radio set at this adjustment, the subject moved to the other side of a large room and put on one of the six headphones which had been connected in the output of the Ear Aid. The DeForest microphone used in the Ear Aid was then moved up close to the radio set loudspeaker and then gradually moved away until the speech, as reproduced in the Ear Aid headphone was once more barely understandable to the subject. The point at which this occurred was exactly six feet from the loudspeaker.

This ratio of 8 inches to 6 feet is the sensitivity gain and actually represents a gain of approximately 81 provided by the Ear Aid, because sound intensity varies inversely as the square of the distance. This does not represent the ratio of true distance gain for the listener, because his headphone may be fifty feet or more from the microphone without introducing any appreciable loss.



TWO TYPES OF HEADPHONE HOLDERS

The headband is normally preferred by men, while the extension handle, shown at the right, is the usual choice of women

This test panel is shown in one of the accompanying photographs.

Tests with this panel connected directly into the output tip jacks of the Ear Aid showed that the best method of connecting the six headphones was to put them all in series, each of them shunted with its individual volume control. These individual volume controls are, of course, an essential to permit each listener to vary the volume at his headphone to meet his particular requirements.

The fundamental circuit for a group output system is shown in Figure 1. Each of the volume-control potentiometers has a resistance of 10,000 ohms; the headphones are the Trimm 1000-ohm "featherweight" type. These headphones were selected because their impedance at average voice frequencies, together with the shunt impedance of the volume controls, provides a more nearly correct load for the amplifier tube in the Ear Aid than would six of any other type headphones tested. With six of these 'phones in the circuit and with each volume control set for maximum volume, the total load on the tube, at 600 cycles, is within about 1% of its rated impedance. As volume is decreased at each phone the overall impedance of the output load goes up, but, as the usual practice is to work an output tube into a load of twice the tube impedance, this increase in load impedance is of relatively small importance, particularly as maximum tube efficiency is not required when the listeners do not require a high volume level. Other makes of headphones now on the market all have considerably higher impedances at voice frequencies than does the one specified here and would therefore offer a less effective match.

Normally, in a church or hall, the microphone would be placed within three or four feet of the speaker. Using the above ratios, therefore, it is evident that a person having the same degree of hearing loss as the subject used in these tests would, by means of the Ear Aid group system, be able to hear the speaker at any point in the hall as well as he would were his unaided ear within four to six inches of the speaker's lips.

Now the only question that may occur is just how deaf is a person with a 60% hearing loss. This is rather difficult to describe. However, readers will gain some idea of the degree when it is stated that such a person can hear nothing of ordinary conversation—even the sound of the speaker's voice—where the speaker is four or five feet from the subject. Sitting in the front pew of a church, he would probably hear the sound of the preacher's voice, but not well enough to distinguish the words. With the equipment described here, and with its microphone on or near the pulpit, this same person could sit anywhere in the church and hear every word distinctly. In fact, if the microphone were within five or six feet of the preacher he would find it necessary to reduce the volume by means of his individual volume control.

To install the Ear Aid in a hall or church, no changes are required, except that the headphone wiring system is connected to the headphone jacks on the inside panel, in place of the single headphone employed when

using the Ear Aid as an individual hearing device. It is not necessary to employ larger batteries unless the system is to be used a great deal. At the rate of ten hours use each week, the flashlight cells will last for several weeks. No extra drain is imposed on either these or the B battery by the use of extra headphones. Therefore, the life of both will be the same as that described in the Ear Aid article in the January issue.

The wiring for the headphones should be permanently installed, usually by running it from the Ear Aid (which may be concealed within the pulpit, with only the microphone on top) down into the basement and along the basement ceiling to the locations of the various outlets. Each outlet should consist of a small box containing the volume control and a single-circuit (open) jack. These boxes, specified for this purpose, can be fastened under the front edge of the seats so that when a headphone is plugged in the cord will not obstruct the passage in front of the user. Also, with this arrangement the user has easy and unobtrusive access to his volume control.

Ordinarily a single headphone will be adequate for each deaf person. Men will usually prefer them equipped with headbands, but women prefer them with handles, as a headband cannot be worn with a hat, and even without a hat it is likely to muss up the hair. Whether a headband or handle, it is of course desirable to include headphones of the lightest weight—which is another point in favor of the make specified above.

The outlets may be located anywhere. The only purpose in keeping them up toward the front is to simplify the wiring. So far as effectiveness is concerned, they can just as well be at the rear of the hall. Nor is it necessary to group them together, although the installation wiring cost is kept down to a minimum by so doing.

In conclusion, it might be pointed out that more than six headphones may be used with the Ear Aid, but in such an event it is best to connect them in series-parallel. However, it is recommended that the equipment to be described next month be employed where more than six outlets are required, as this new equipment will provide the greater volume and power required for larger installations.

List of Parts for a Six-Outlet System

RADIO NEWS Ear Aid, complete, as described in January issue, less headphone

6 Broderick headphone outlet boxes for mounting on under side of seat (each box includes one 10,000-ohm wire-wound potentiometer and one single-circuit open jack, mounted and wired)

6 Trimm 1000-ohm "featherweight" headphones, complete with cords and either handles or headbands

Wire, staples, etc., for installation wiring

What Tube Shall I Use?

(*Continued from page* 851)

by a loudspeaker in rooms of various sizes, from those who wish volume enough to be heard several blocks away to those who like a set adjusted low enough to make conversation possible without shouting.

Where good quality reproduction without perceptible distortion is required for home use with a magnetic speaker, it is advisable to use an output tube or combination of tubes which will give an undistorted power output of 500 to 750 milliwatts.

Suitable Power

In general, an amplifier capable of delivering from 1750 to 2500 milliwatts, with a suitable dynamic speaker to handle that power without overloading, is considered sufficient for the average living room. Larger rooms, such as are found in some homes, may logically require an amplifier capable of delivering 3000 to 6000 milliwatts, obtainable by using a single stage -50 or push-pull -45 or -47 tubes.

Club rooms and auditoriums can utilize amplifiers and speakers rated at undistorted power outputs of 6000 and more milliwatts, obtainable by parallel, push-pull or combination arrangements of -45, -47 or -50 tubes.

Outdoor public address installations, of course, require heavy-duty amplifiers, the output power and number depending on the area over which good reproduction is required, and the noise level of the location.

It is unfortunate that loudspeaker manufacturers have not seen fit to mention in their specifications the undistorted power-handling ratings of their speakers. This omission makes it somewhat difficult for the amplifier designer to determine the loudspeaker which must be used for a given power output.

A fair idea of the power-handling capacity of dynamic speakers can be gained from the manufacturers' specifications which mention the power tubes for which the speakers are designed.

Thus speakers designed for use with two -71A tubes in push-pull can be given an undistorted power-handling rating of approximately 1750 milliwatts maximum; those designed for two -45 tubes in push-pull can be given a maximum rating of 5000 milliwatts; those designed for two -47 tubes in push-pull can be given a maximum rating of 6250 milliwatts and those designed for two -50 tubes in push-pull can be given a rating of 11,500 milliwatts. Generally, however, the actual rating is higher, due to the factor of safety built into such speakers to take care of overloads.

Cone speakers such as the old Western Electric type can usually handle up to about 1.5 watts without striking the pole pieces at the lower frequencies, and that is the maximum power which should be fed to them if distortion at the lower frequencies is to be avoided on high volume.

A speaker designed for use with a power tube or combination of tubes capable of providing a given undistorted output can of course be used with any other tube or combination of tubes which will furnish the same amount or somewhat lower value of undistorted power output, providing, of course, that the coupling transformer between the power stage and speaker is designed to match the new combination.

Low Note Energy

It must be remembered, of course, that the maximum power rating mentioned for the loudspeakers is the maximum power used for the undistorted reproduction of the very low notes. The power output of an amplifier and the power required by a loudspeaker to reproduce high frequencies is much lower than that required for the low frequencies.

Next month the second of this series of articles will continue with a detailed discussion of the considerations involved in the choice of power tubes. A detailed table will be included, showing at a glance the tubes or tube combinations required to meet any set of conditions in the power output stage.

The Complete Service Unit

(*Continued from page 856*)

of an old audio transformer or choke.

The resistance of the 150-volt multiplier for the a.c. meter will depend, of course, on the resistance of the meter. Assuming that the constructor has already ascertained the resistance of the meter, he may use the following formula to determine the resistance of the multiplier R21:

$$R^x = \frac{E^R - E^M}{I^M}$$ where R^x is the resistance of the multiplier, E^R the voltage range desired, E^M the present maximum voltage range of the meter, and I^M the current the meter draws for full-scale deflection. Electrad type B, 25-watt resistors are advisable, because with them the exact resistance may be adjusted by means of the sliding clip and an ohmmeter. In determining the resistance of the 1200-volt multiplier R22, the above formula may be used with a slight change in the E^M value. This E^M value should be changed to voltage range just obtained, that is, 150 volts. The maximum wattage rating of the multiplier is the I^2R, where I is the current flowing through the resistor and R its resistance in ohms. Due to the large voltage drop occurring across the multiplier, two resistors, each having half the total resistance, should be used connected in series. Electrad type C, 50-watt resistors are quite suitable if they can carry the required amount of current. Refer to the Electrad catalog for the current-carrying capacities of these resistors. Adjust these resistors to their correct value as with the 150-volt multiplier.

On the top part of the meter's double-range scale will be found space enough to mark a new 150-volt or 1200-volt range.

When using the current transformer the button S7 must be pressed in order to connect the 3-volt instead of the 15-volt range across the transformer secondary. The P-P position of selector switch S2 is for measuring total secondary voltage from plate to plate on a 280 rectifier.

The following are analytical readings obtainable with tester plug inserted in radio set:

Filament voltages on any voltage range desired—heater voltages on the 3 or 15-volt range of the a.c. meter—plate voltages from 10 to 1000 volts—plate current on the 10 or 100 ma. range—grid voltage from 10 to 1000 volts, grid current on the 2, 10 or 200 ma. range—also screen-grid voltage and current on the above ranges—screen control grid voltage on any voltage range—cathode voltage, either positive or negative, on any voltage range—power pentode screen-grid voltage on any voltage range—power pentode screen-grid current on the 10 ma. range—space-charge grid voltage on r.f. pentodes, any voltage range—current of both plates of -80 rectifier tubes—plate to heater voltage on -80 rectifier, any voltage range—total secondary voltage plate to plate on 1200-volt range of the a.c. meter. The grid test button S9 changes the grid bias of the tube being tested by 4.5 volts. The resultant change in plate current indicating the condition of the tube. Voltmeter return switch is used while testing pentode tubes. It should normally be in the K position when testing tubes other than pentodes.

A few words of caution will not be amiss here. It is imperative that the radio set be turned "off" before the "GMa" button S12 is pressed. To prevent damage to the d.c. meter, never press the "Ma" button S14 when measuring voltages.

The five-foot-seven wire analyzer cable is soldered directly to the prongs of the Naald analyzer plug. Solder the space-charge grid wire to the latch of the plug and the screen control grid wire to the metal cap on the handle.

List of Parts

M1—Jewell Pattern 88, 0-1 d.c. milliammeter
M2—Jewell Pattern 78, 0-3-15 a.c. voltmeter
R1—Yaxley No. 5400 P, 400-ohm variable resistor
R2—Yaxley No. 55000 P, 5000-ohm variable resistor
R3— 10,000-ohm resistor
R4—100,000-ohm resistor
R5—150,000-ohm resistor
R6—250,000-ohm resistor
R7—500,000-ohm resistor
} International Resistance Co. type WW1 (accurate 1%)
R8, R11, R13, R15, R17—10 ma. shunts made according to text
R9, R12—50 ma. shunts made according to text
R10, R14, R16—100 ma. shunts made according to text
R18—2 ma. shunt made according to text
R19—Acratest 4000-ohm, 3-watt carbon resistor
R20—Acratest 2000-ohm, 3 watt carbon resistor
R21—Electrad type B, 25-watt resistor for 150 volts a.c. range
R22—Two Electrad type C, 50-watt resistors for 1200 volts a.c. range
C1, C2—Dual Acratest .1-0-.1 mfd. condensers, 200 volts d.c.
C3, C6—Aerovox type 1460, .0005 mfd. condensers
C4, C7—Aerovox type 1460, .005 mfd. condensers
C5—Aerovox type 1460, .001 mfd. condensers
13 Jewell locking push-buttons for switches S7 to S19 (see text)
S1—Weston 9-point bi-polar switch
S2—Best 5-point bi-polar switch
S3—Yaxley 9-point tap switch
S4—Toggle switch, s.p.d.t.
S5, S6—Cutler-Hammer 3-point toggle switches
S7, S10—Push-button switches, s.p.d.t. (see text)
S8, S9, S12, S13—Push-button switches, d.p.d.t. (see text)
S11—Push-button switch, t.p.s.t. (see text)
S14, S15, S16, S17, S18, S19—Push-button switches, s.p.s.t. (see text)
L1, L2—Oscillator coils (see text)
SH—Grebe screen-grid coil shield
VT1, VT4—Pilot No. 216 four-prong sockets
VT2, VT3—Pilot No. 217 five-prong sockets
RFC1, RFC2—Radio-frequency chokes (see text)
F1, F2—Small radio cartridge fuses, 1 amp.
PL—Yaxley pilot light and bracket, 6 volts
B1—Burgess No. 5360, 4.5 C battery
CD—Fixed crystal detector
T1—Tube checker filament transformer (see text)
T2—A.C. meter current transformer (see text)
J1 to J16—I.C.A. tip jacks
OR—Hart and Hegeman outlet receptacle
Naald No. 905L analyzer plug, No. 954 DS lock-on adapter
5-foot, seven-wire cable
1 Pilot No. 214 four-prong socket (for adapter)
2 Pilot No. 215 five-prong socket (for adapter)
2 UX tube bases (for adapters)
1 UY tube base (for adapter)
¼ lb. No. 18 enameled wire
¼ lb. No. 24 enameled wire
¼ lb. No. 32 enameled wire
I.C.A. ¼-inch bakelite panel, drilled and engraved, 4½ inches by 16⅞ inches; 3/16 inch bakelite panel, 3½ inches by 8½ inches

The Twin-Grid Tube

(*Continued from page* 840)

the potential difference of grid circuits x and x^1 which is shown as the difference from (a) to (b). Now if the two grid currents x and x′ be supplied from the same source at opposite phase or reversed polarity, and a variable resistance placed in one circuit, any variations in the current supply will occur in both circuits, but with lesser amplitude in one circuit, the degree of difference depending on the amount of resistance in the circuit.

For the purpose of explanation, let it be assumed that this common source is supplying a positive and negative biasing charge of 10 volts to each grid circuit respectively, and that the resistance is cut in the positive circuit and adjusted until it has half the value of the negative bias, or 5 volts. Thus, the resulting potential value of the total grid charge acting on the electron stream is negative 5 volts, which will result in a decrease of 2 milliamperes in the plate current. Now suppose that the value of the common source is suddenly doubled, supplying 20 volts instead of 10. This changes the potential value of the grid bias from negative 5 volts to negative 10 volts, resulting in another 2 milliampere decrease as compared to the negative 5-volt reading, or a total deflection of 4 milliamperes as compared to normal plate current flow without grid bias. Operating under the same conditions, a 20-volt bias (negative) on a three-element tube results in an average drop of 8 milliamperes, or twice that of a twin-grid tube when the duplicate potentials have a ratio of 2 to 1.

Operating under the same conditions as above, the amplitude of plate current variations may be further decreased by decreasing the amount of resistance in the grid current. For example, suppose that the common source is supplying a 10-volt bias as before, and that the resistance is adjusted until the positive bias reads 8 volts. The potential value of the total grid charge is now negative 2 volts, which will result in a deflection of 1 milliampere in the plate circuit current. When the value of the common source is suddenly doubled, supplying 20 volts, the potential of the total force acting on the electron stream is negative 4 volts, which results in a deflection of less than 2 milliamperes in the plate current.

Thus it will be seen that when suitably arranged, the twin-grid tube will serve effectively as an automatic plate current control in which the amplitude of plate variations depends on the potential difference of the grid biasing currents rather than on the amplitude of grid variations. Such a circuit arrangement is illustrated in Figure 5, where the current to be regulated is coupled to the twin-grid balance tube through a suitable transformer so that any variations in the supply current is induced at opposite phase on the duplicate grid element simultaneously, the difference of potential being controlled by variable resistance. The output of the tube may be amplified to any desired strength through suitable amplifying arrangement.

The circuit may be used as an automatic volume control in the broadcast receiver, no station being received above a set signal strength as may be selected by the operator, thus eliminating the unpleasant "blooping" encountered when crossing the frequency band of local or high-powered stations during the process of tuning or station selection. The arrangement may also be used effectively in microphone circuits to prevent overloading of the amplifier circuit from sudden variations in sound intensity.

Next month various other applications of the new tube will be described. These will include its use as an eliminator of static and other interference of indefinite frequency, as a combination oscillator and modulator for transmission, as a combination detector and oscillator for superheterodynes and as a dual-purpose tube in reflex receiver circuits.

Graphs and Charts

(*Continued from page* 860)

OA, OX and OB when A, X and B are on a straight line.

The solution is found in the same way as in previous examples, in the March and February issues of RADIO NEWS.

Draw the two rectangular triangles ACX and XDB. Since these triangles are similar, we can write

$$\frac{CX}{AC} = \frac{DB}{XD}$$

$$\frac{OX - OA \cos p}{OA \sin p} = \frac{OB \cos q - OX}{OB \sin q}$$

Removing fractions:

$$OB.OX \sin q - OA.OB \cos p \sin q = OA.OB \sin p \cos q - OA.OX \sin p$$

Solving for OX:

$$OX(OA \sin p + OB \sin q) = OA.OB(\cos q \sin p + \cos p \sin q)$$

or

$$OX = \frac{OA.OB(\cos q \sin p + \cos p \sin q)}{OA \sin p + OB \sin q} \quad (1)$$

From trigonometry: $\cos q \sin p + \cos p \sin q = \sin(p + q)$. Substituting this in the equation (1) and writing it in the desired form:

$$\frac{1}{OX} = \frac{\sin q}{\sin(p+q)} \cdot \frac{1}{OA} + \frac{\sin p}{\sin(p+q)} \cdot \frac{1}{OB} \quad (2)$$

When the modulus on the three scales is also taken in consideration, OX, OA and OB must be replaced by their respective values

$$xM_x,\ aM_a \text{ and } bM_b$$

The formula then becomes

$$\frac{1}{x} = \frac{M_x \sin q}{M_a \sin(p+q)} \cdot \frac{1}{a} + \frac{M_x \sin p}{M_b \sin(p+q)} \cdot \frac{1}{b}$$

Geometrical Construction

Figure 3 shows the principle of constructing the symmetrical chart. A constructional line drawn through division 50 on the center scale and perpendicular to it, intersects both slanting scales at division 100. All other lines, parallel to it, pass through divisions on the slanting scales which indicate twice that of the one in the center.

In the case of a non-symmetrical scale, the construction is made as in Figure 4. The constructional lines form parallelograms and the numbers are the same at three angles.

These constructions are easy to understand, for in each case they are really sample calculations as we described last month, under the subhead, "The Automatic Method."

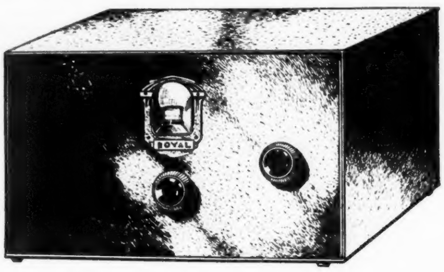
What's New in Radio

A department devoted to the description of the latest developments in radio equipment. Radio servicemen, experimenters, dealers and set builders will find these items of service in conducting their work

By The Technical Staff

Short-Wave Receiver

Description—A compact two-tube battery-operated short-wave receiver with a wavelength range of 14 to 200 meters. The set uses one -32 screen-grid type tube and one -33 pentode tube. It features a micro-vernier, sector-vision tuning dial and is designed to operate from any size antenna.



All receiver parts are mounted on a cadmium plated chassis which is enclosed in an attractive metal cabinet measuring 11 inches by 7 inches by 6½ inches. With an additional coil, the tuning range can be extended to 550 meters. This company also makes a short-wave receiver of special design for amateur use, utilizing band-spread coils and condenser combinations covering the 20, 40 and 80-meter wavelengths.

Maker—Royal Short Wave and Television Co., 191 Franklin St., New York City.

The Three-Purpose Electric Clock

Description—An electric clock designed for three separate functions. First, to provide an accurate timepiece. Second, a 24-hour alarm clock that requires no re-setting, once it has been set for the desired time. Third,

an electric alarm "notifier" which can be set for any time interval, from a half minute to three hours. This "notifier" feature is adaptable to many applications and should find favor with the radio enthusiast as a reminder to tune in for a favorite radio program at the specified hour, etc. The clock is enclosed in an attractive metal case with black numerals on a silvered dial. It measures 6½ inches high by 5 inches wide.

Maker—Chicago Flexible Shaft Co., Roosevelt Rd. and Central Ave., Chicago, Ill.

Photo-Electric Cell

Description—The Weston Photronic cell transforms light energy directly into electrical energy by means of a highly light-sensitive disc. This cell requires no polarizing or exciting voltages and can operate a relay directly, without an auxiliary amplifier. It delivers approximately one microampere per foot-candle of light intensity. When exposed to direct sunlight, the output is approximately five milliamperes. The cell resistance varies from about 1500 ohms for 10 foot-candles light intensity to about 300 ohms for 240 foot-candles intensity. It is enclosed in a moulded black bakelite case measuring 2¼ inches in diameter by 1 inch in thickness, and is equipped with two con-

nection prongs at the bottom of the case, to fit into the UX type vacuum tube socket.

Maker—Weston Electrical Instrument Corp., 615 Frelinghuysen Ave., Newark, N. J.

Moisture-Proof Condenser

Description—A new type condenser sealed at both ends against moisture so as to retain its original high resistance and to in-

sure long life with satisfactory service. The illustration shows a standard 1 mfd. surgproof condenser which has been submerged in water continuously for 240 hours and when the condenser was tested it showed no loss in resistance. The loop leads may be cut at any desired point for conveniently reaching any part of the circuit. The various color code wrappers indicate the differ-

ent working voltages of the condensers. These units are obtainable in service type for power unit repair work and in tubular by-pass type, ranging in capacity from 0.1 mfd. to 2 mfd. and in working voltages from 300 to 1,000 volts.

Maker—Tobe Deutschmann Corp., Canton, Mass.

A New Line of Vacuum Tubes

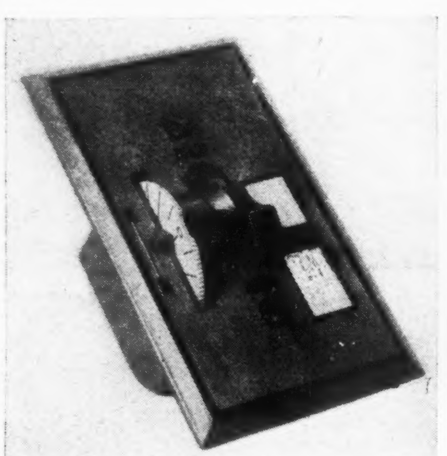
Description—The new CeCo Citation vacuum tubes, made in -24, -47, -27, -35, -45 and -80 types, are subjected to more exacting tests and closer inspection limits

than the regular CeCo tube. Each tube has to undergo a 24-hour continuous operating test under actual receiving-set conditions. After this, the tube is retested on special meters before it is packed for shipment. This new tube is enclosed in an attractively designed gold and black modernistic box.

Maker—CeCo Manufacturing Co., Inc., 1200 Eddy St., Providence, R. I.

A Switching Control for the Radio Receiver

Description—This Mark-Time, model H-12, type AA switch is an "off" or an "on" automatic switching device, adaptable to numerous electric appliance and lighting applications. This unit is interchangeable with the standard single-gang wall switch. It is equipped with a calibrated control dial for adjusting the time interval. The large exter-

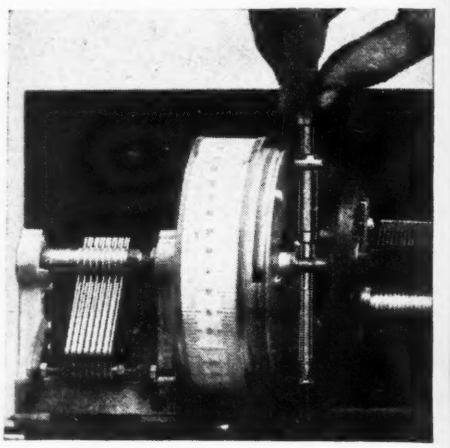


nal left-hand dial is marked in fifteen-minute divisions and the smaller internal dial is shown in one-hour divisions. A complete revolution of these dials provides five hours delay. The unit has a 12-hour time limit. When the dial is turned back to zero marking, the device is a standard "on-off" switch. Each switch is complete with instructions for installation as well as a template for mounting in a radio cabinet. Other available Mark-Time switches include the type BB that turns itself "on" or "off" automatically and is equipped with an inbuilt receptacle to plug in the electric appliance. The type DAA is a duplex control switch that can turn current on at any desired time and off at another predetermined time.

Maker—M. H. Rhodes, Inc., Hartford, Conn.

A Convenient Screw-holding Screw Driver

Description—Fulfilling a real need for the mechanic and radio serviceman, the Jiffy-Tite tool introduces a novel and practical achievement in a one-hand-operated, screw-holding, screw-driving instrument. A gripping lever cut in the center of the tool blade moves in or out at will of the operator, to grip or release the wood or machine screw, by its slot. This gripping lever is controlled by a knurled slide mounted close to the handle. The tool is especially adapted to confined locations and for jobs of long reach where the screw must be started at arm's length. The instrument measures 9 3/16 inches long and is 5/16 inch wide.



The junior type is 8½ inches long, the blade measuring 3/16 inch wide.

Maker—Millen Manufacturing Co., 7 Water St., Boston, Mass.

Motor Radio Suppressor Kit

Description—This kit, containing a suppressor unit for each spark plug and a sup-

pressor for connection in the main distributor lead, is accompanied by a folder giving complete information with diagrams on the installation and use of suppressor units and filter condensers for the suppression of automobile radio noises. These suppressors are shock-proof, unaffected by heat and are non-combustible. The capacity of the units is less than ½ micro-microfarad. The kits are obtainable for four, six and eight-cylinder automobiles. If desired, individual suppressors are available.

Maker—International Resistance Co., 2006 Chestnut St., Philadelphia, Pa.

Receivers for the Farm

(*Continued from page 835*)

service with full efficiency at all times. This is a new and totally different kind of battery. Its electrical characteristics are unlike those of the more familiar type of "A" batteries and it is to be used only with receivers designed for its employment. When designing a home-constructed set the important fact to keep in mind is that the total amount of courrent this battery can safely deliver is a maximum 0.65 ampere. If connected to any device that consumes more than this amount the Air-cell battery will be quickly and permanently ruined.

The battery is so named because it operates on a principle of air depolarization. A special kind of carbon electro breathes the oxygen out of the air and into the battery, and the amount is automatically regulated to the current consumed by the receiver. As there is an unlimited amount of oxygen, the working voltage of the unit remains constant throughout its complete life.

The 2-volt type tubes employed in these receivers require only a small amount of "A" battery current and it is possible to operate a seven-tube set, utilizing five tubes of the -32 or 30 type and two -31-type tubes in a push-pull, power-output stage and not consume over -0.56 ampere of current from the the Air-cell. This is well below the maximum safe limit of 0.65 ampere.

The required "B" and "C" batteries complete the operating equipment of these Air-cell receivers.

Radio News Technical Information Service

The Technical Information Service has been carried on for many years by the technical staff of RADIO NEWS. Its primary purpose is to give helpful information to those readers who run across technical problems in their work or hobby which they are not able to solve without assistance. The service has grown to such large proportions that it is now advisable to outline and regulate activities so that information desired may come to our readers accurately, adequately and promptly.

Long, rambling letters containing requests that are vague or on a subject that is unanswerable take up so large a portion of the staff's working time that legitimate questions may pile up in such quantities as to cause a delay that seriously hinders the promptness of reply. To eliminate this waste of time and the period of waiting, that sometimes occurs to our readers as a consequence, the following list of simple rules *must* be observed in making requests for information. Readers will help themselves by abiding by these rules.

Preparation of Requests

1. Limit each request for information to a single subject.
2. In a request for information, include any data that will aid us in assisting in answering. If the request relates to apparatus described in RADIO NEWS, state the issue, page number, title of article and the name of the device or apparatus.
3. Write only on one side of your paper.
4. Pin the coupon to your request.

The service is directed specifically at the problems of the radio serviceman, engineer, mechanic, experimenter, set builder, student and amateur, but is open to all classes of readers as well.

All questions from subscribers to RADIO NEWS will be answered free of charge, provided they comply with the regulations here set forth. All questions will be answered by mail and not through the editorial columns of the magazine, or by telephone. When possible, requests for information will be answered by referring to articles in past issues of the magazine that contain the desired information. For this reason it is advisable to keep RADIO NEWS as a radio reference.

Complete information about sets described in other publications cannot be given, although readers will be referred to other sources of information whenever possible. The staff cannot undertake to design special circuits, receivers, equipment or installations. The staff cannot service receivers or test any radio apparatus. Wiring diagrams of commercial receivers cannot be supplied, but where we have published them in RADIO NEWS, a reference will be given to past issues. Comparisons between various kinds of receivers or manufactured apparatus cannot be made.

Only those requests will be given consideration that are accompanied by the current month's coupon below, accurately filled out.

APRIL, 1932
Technical Information Coupon
RADIO NEWS Laboratory
350 Hudson Street
New York, N. Y.

Gentlemen:

Kindly supply me with complete information on the attached question:

☐ **I am a regular subscriber to RADIO NEWS and I understand this information will be sent me free of charge.**

☐ **I am not yet a subscriber to RADIO NEWS.**

☐ **I wish to become a subscriber to RADIO NEWS and enclose $2.50 to receive the magazine regularly for one year, and to receive this valuable technical information service free of charge.**

Name ....

Address ....

The Service Bench

(*Continued from page* 864)

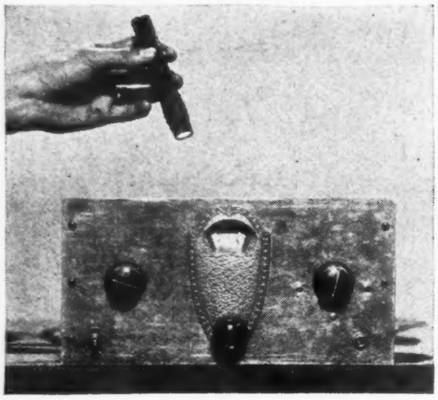


Figure 4. The handy flashlight that simplifies many a tight service job. It's worth in dollars what it saves in cuss-words

Westinghouse WR4

J. A. Robinson, proprietor of Robinson's Radio Service, Methuen, Mass., and a consistent contributor to the Service Bench, comments on instability in a Westinghouse WR4. "This receiver is of the tuned radio frequency type, using three S. G. tubes in the r.f., also in the detector, and push-pull '45s in the output. Chassis and tubes, except the '45s and the '80, are in a vertical position. The set is very well shielded—and therein lies the source of trouble.

"If the receiver persists in oscillating, and a change in the r-f tubes will not stop it, remove the chassis from the cabinet. On the side opposite to the tube shields you will find a large shield covering the gang tuning condenser assembly. You will find inside of this can four compartments, and in each a small clip which fits over the shaft of the rotors. Be sure that these clips make good contact, and the receiver will not oscillate again until they become dirty."

(In other words, when oscillations are persistent and baffling make sure that all shields, and particularly shield covers are well grounded.—Ed.)

Sparton "931"

Our standby contributors are in good form this month, and Russell Woolley, Seattle, Washington, passes on the following dope: Nine times out of ten, a burned-out power transformer in a Sparton '931' is caused by a "shorted" element in the rectifying tube, and indirectly due to a defective grid-bias resistor in the power-tube circuit. This resistor is a carbon one, grounded under a bolt of the transformer mounting, connected to a lug of the filament winding of the C-183 Sparton power tubes. It disintegrates, decreasing the grid voltage and increasing the current drain up to 100 mils per tube, which of course ruins the rectifier and burns out the power transformer as the filament sputters against the plate. The tone quality of the set is only slightly affected until the transformer actually begins to smoke—at which time it is too late to do anything but replace it. The correct replacement resistor value is 1200 ohms—wire wound. A special resistor is sold by Sparton dealers at 60c net and the power transformer at $9.00 (west coast prices)."

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The following manufacturers have prepared interesting literature which for the convenience of readers RADIO NEWS can supply, free of charge, to any serviceman requesting same on this letterhead. These catalogs are not listed indiscriminately, and

The Service Bench

only after detailed inspection to determine their value to the serviceman. Simply address your requests to RADIO NEWS, Department ML, 350 Hudson St., New York.

CARTER RADIO CO. Circulars: "Carter Transformers," containing useful data on the design of power supply circuits. "How to Wire Buildings for Radio," containing interesting and useful material on convenience outlet plates, and the operation of two or more receivers from a single antenna.

ELECTRAD, INC. "Electrad Replacement Volume Controls and Resistors." An instructive and practical replacement guide.

PILOT RADIO AND TUBE CORP. "Service Manual on Pilot Supers" and "Service Manual on Pilot Converter." Both books contain much information on general receivers and converters of this type, as well as specific data on the Pilot models.

Radio Physics Course

(*Continued from page 869*)

and no strains can be set up by heating or cooling, as the vitreous enamel and the wire expand and contract together. Figure 1 shows a resistor of this type during the various stages of manufacture, from the bare porcelain base tube at one end to the completely vitrified resistance winding at the other end. This is a voltage divider resistance used in power packs. Special resistance wires made from alloys of nickel and iron have been developed for winding these resistors. They have very low temperature coefficients of resistance and therefore their resistance does not change very much when they get warm in service. Several resistors of this type made up in special forms for use in radio receivers are shown in Figure 2. Resistor H is variable in value in steps.

RADIO NEWS Export Service

AS a service to our readers in locations outside the United States of America, either commercial, professional or private individuals, RADIO NEWS will arrange to provide contact with leading American manufacturers of radio supplies and receiving equipment.

To utilize this service, clip and fill out coupon below and send it attached to your letter on which you list the types of apparatus you are interested in.

Our Export Service Department will refer your inquiries direct to the proper manufacturers, asking them to send you full particulars, catalogues, prices, etc.

* * *

ALS einen Dienst für unsere Leser, entweder Kaufleute oder Privatpersonen ausserhalb der Vereinigten Staaten von Amerika, kann RADIO NEWS mit den führenden Amerikanischen Fabrikanten von Radio Apparaten Kontakt herstellen.

Für den Gebrauch dieses Dienstes schneide man den Kupon aus und sende denselben mit einer Liste von Apparaten die für Sie von Interesse sind.

Unsere Export Abteilung wird Ihr Schreiben umgehend an die betreffenden Fabrikanten weiter befördern, mit der Bitte Ihnen Auskünfte, Preise und Kataloge zu senden.

* * *

COMME un service à nos lecteurs demeurant hors des Etats-Unis d'Amérique, soit établissements commerciaux, soit personnes privées, RADIO NEWS arrangera de procurer le "contact" avec les usines les plus importantes des appareils de T. S. F. en Amérique.

Pour utiliser ce service, coupez, signez, etc., le coupon sur cette page et envoyez le attaché à votre lettre en énumerant les types des appareils qui vous intéressent.

Notre Département d'Exportation fera suivre vos requêtes aux manufacturiers directement en les priant de vous envoyer toutes informations, catalogues, prix, etc.

* * *

COMO un servicio especial a nuestros lectores que se encuentran fuera de los Estados Unidos de America, ya sean comerciantes, profesionales o personas privadas, RADIO NEWS tendra a bien ponerlas en contacto con los principales centros manufactureros de radio, de aparatos receptores y accesorios.

Para beneficiarse de tal servicio, sirvase recortar el coupón de esta página, enumere los tipos de aparatos que le interesen, y envienosla con su carta.

Nuestro Departamento de Exportación se encargará de ponerse en contacto directo con dichos centros, pidiendo le envien información completa, catalogos, precios, etc.

* * *

RADIO NEWS Export Service Department

Kindly put me in contact with American firms manufacturing the class of radio apparatus noted on attached sheets.

Name...

Address...

Business...

With the Experimenter

(Continued from page 867)

cone which carries the voice coil touches the field magnet.

To remedy this condition, loosen the reproducer's clamp nuts at the rim which holds the chamois skin or leather, carefully rub the skin between the fingers until it becomes again soft and pliable and then put it back very loosely in the rim. In Majestic or similar types having a metal "spider" held to the field magnet by a small screw, make the hole through which this screw passes a little larger, the frame may then be adjusted accordingly.

BENJAMIN J. SPOTTS,
Philadelphia, Pa.

Warning on Static Reducer

I am a reader of RADIO NEWS and wish to sound a warning about an article published in the "With the Experimenters" section of January RADIO NEWS, page 597, entitled: "Simple Static Reducer".

Don't try this with the Majestic receivers, at least not in the late series. I find that when the ground is applied to the aerial this in turn shorts the a.c. line through the volume control, which results in burning an open place in the volume control resistance strip. I agree with Mr. Unterberg, that this system will eliminate static and increase volume, but, at the expense of a new volume control. I have had to replace, to date, four volume controls in the late series of Majestics due to the salesmen connecting the ground to the aerial posts for demonstration of these sets.

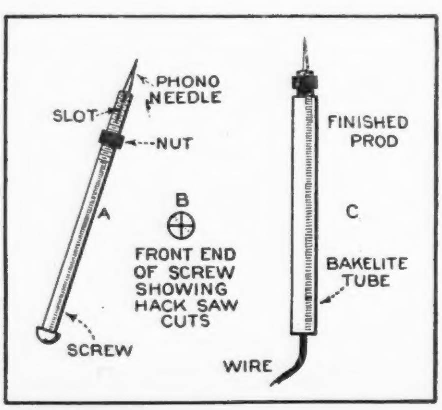
If, when the aerial is grounded as Mr. Unterberg suggests, the lead-in is connected to the antenna post on the set, notice if it sparks, if so remove the wire at once. Place a one or two mfd. filter condenser in series with the wire leading from the far end of the aerial to the ground and this will remove the danger and the static reduction action is the same, when the wire is again connected to the antenna post of the receiver.

W. T. GOLSON,
Baton Rouge, La.

Home-Made Test Prods

The writer, being badly in need of a pair of test prods and lacking the money to buy good ones, devised the following arrangement from simple parts out of the junk box.

I took a three-inch screw and the thickest obtainable nut to fit it. The nut was screwed well up onto the shaft of the screw and then a cross-like pair of slots (see A and B, Figure 00) was cut in the threaded end of the screw. This leaves an opening at the intersection of the cuts and into this opening a phonograph needle was forced. This last operation spreads the end of the screw somewhat.



By screwing the nut down onto this ex-

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panded portion, the phonograph needle is firmly clamped in place.

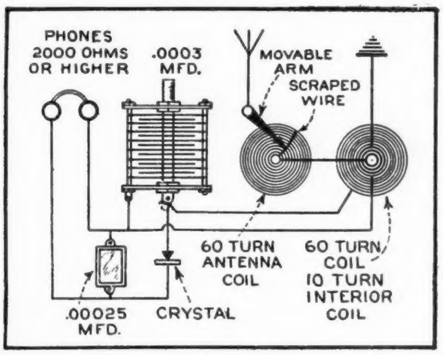
The only thing then was to "dress up" the screw to make it more presentable in appearance, as shown at C. The connection wire may be soldered directly to the head of the screw.

SAM TROUCOSS,
El Paso, Texas.

1250 Miles with a Crystal Detector

An item appeared under this title in "With the Experimenters" department in the January issue. Our attention has since been called to the fact that the circuit diagram was incorrect. The correct diagram is herewith shown. A surprisingly large number of inquiries have been received from readers for information concerning this crystal receiver, both by Mr. Howard Byrne, the author, and by RADIO NEWS.

Mr. Byrne writes that in his receiver he has the coils mounted at right angles. The antenna coil is placed flat on the baseboard while the other coil is mounted in a vertical position. The coils are of the spider-web type, wound on a form having thirteen legs. The number of turns for each coil is shown on the diagram. All windings employ number 22 d.c.c. wire.



There are undoubtedly many readers who will be interested in obtaining this additional information concerning this receiver. Incidentally Mr. Byrne has been adding to the list of stations received. His little crystal set now has to its credit the reception of 25 stations with an average distance per station of 641 miles.

With the Experimenter

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varying the resistance R5. The motor rotates only as long as there is an unbalanced condition in the bridge and it immediately comes to rest when a balanced condition is obtained.

In the system just described it is only necessary to have a resistance with a sliding contact, as well as an automatic circuit switch for the reversible motor (dial D of diagram) and by merely rotating the dial remote tuning is made possible.

STANLEY L. GLAMB,
Detroit, Mich.

Backstage in Broadcasting

(*Continued from page* 865)

with Fatty Arbuckle, Mabel Normand and Charlie Murray. On his present Brooklyn radio programs, Walsh is teamed with Fred Whitehouse under the billing of "Hale and Hearty: the Doctor and the Professor." The programs consist of songs and chatter.

(*Continued on page* 896)

A SERIES of programs produced by an ensemble of ether-wave instruments is a regular Monday feature of the CBS. These instruments have all been heard over the air before on single occasions, but not on a weekly series. The group is known as the Theremin Electro-Ensemble and comprises three types of ether-wave and electrical instruments developed by Leon Theremin, a pioneer in this field. The instruments are known as the electro-cello, the electro-voice, and the electro-piano. The electro-cello looks somewhat like an ordinary cello but lacks the sound box, strings and bow. Tones are obtained by pressing a flexible strip. The electro-voice is played by movements of the fingers and hands at varying distances. The electro-piano has a keyboard but no strings and soundboard. Leonid Bolotine, director of the trio, plays the electro-cello; George Goreff, the electro-voice, and Gleb Yellin, the electro-piano.

THE township of Thompkins Corners has seceded from the NBC and is now within the boundaries of the CBS. George Frame Brown, the Matt Thompkins of the "Real Folks" rural sketch, with his entire cast intact, switched to Columbia under the new sponsorship of the General Foods Company. Mr. Brown you know, was the original Luke Higgins in the Main Street Sketches of WOR. When his affiliation with the Newark station terminated, there was quite a legal fuss as to who owned the idea of the series. Since Brown's departure, WOR has intermittently continued Main Street Sketches. Brown's "Real Folks" series was highly successful on the NBC and the sketch has been kept intact in the transfer to the CBS.

MR. BROWN

News and Comment

(*Continued from page 872*)

Develop Light-Sensitive Units

CHICAGO—With the recent development and extreme sensitivity of photo-electric cells, the jobs that can be done by this newest medium of the electronic industry have been increased a hundredfold and no one can accurately predict the tremendous possibilities of this cell in the fields of modern business and invention. Amateurs who have desired to experiment with photo-electric cells have up till now been held back by price. Now, however, the DeVry Corporation, Chicago, manufacturers of photo-electric cells, have assembled a kit containing everything necessary to build up a photo-electric cell unit which can be utilized in an infinite variety of ways. This kit contains an extremely sensitive photo-electric cell, complete materials for the amplifier, a relay, and is packed complete in a box with full instructions for assembling, and also complete wiring diagrams and instructions for making burglar alarms, light signals, garage-door openers, and other electronic devices. The complete kit sells for only $10.00 and is sold by Herman A. DeVry, Inc., 55 East Wacker Drive, Chicago.